US Army Corps of Engineers

TECHNICAL REPORT CERC-89-5

DUCK85 SURF ZONE SAND TRANSPORT EXPERIMENT

by

Nicholas C. Kraus, Kathryn J. Gingerich, Julie Dean Rosati

Coastal Engineering Research Center

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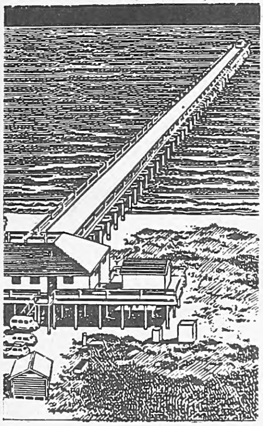

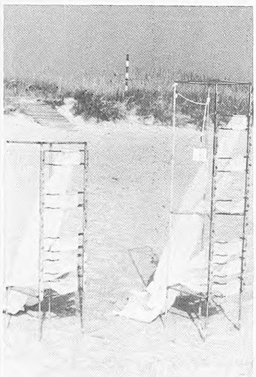

June 1989

Final Report

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Under Surf Zone Sediment Transport Processes
Work Unit 34321

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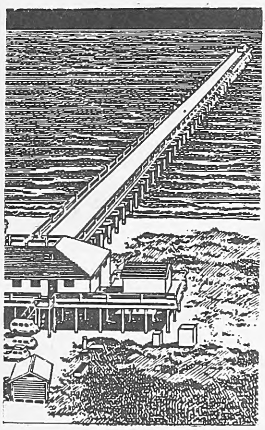

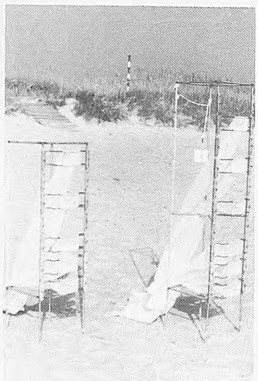

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The procedures and results of an experiment performed to measure the longshore sand transport rate in the surf zone as part of the DUCK85 field data collection project are described in this report. Intended to provide complete documentation of the sand transport experiments, this technical investigation includes a compilation of the collected data. To the authors' knowledge, no previous experiment has directly and synoptically measured the longshore sand flux through the water column and across the surf zone as was accomplished in this project. Valuable data, considered to be unique in completeness and detail, were collected through this program for minimal equipment investment.

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PREFACE

The investigation described in this report was authorized as part of the Civil Works Research and Development Program by Headquarters, US Army Corps of Engineers (HQUSACE). This study was conducted by the Surf Zone Sediment Transport Processes Work Unit No. 34321, under the Shore Protection and Restoration Program at the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). Messrs. John H. Lockhart, Jr., and John G. Housley were the HQUSACE Technical Monitors. Dr. C. Linwood Vincent was CERC Program Manager.

The study was performed by CERC in two phases, a field experiment planned and conducted from 1 June 1985 through 30 September 1985, and subsequent analysis of the data conducted from 1 October 1986 to 30 June 1987. The first phase was performed by Dr. Nicholas C. Kraus, Senior Research Scientist and Principal Investigator, Surf Zone Sediment Transport Processes Work Unit, Research Division (CR), and Ms. Julie Dean Rosati, Hydraulic Engineer, Coastal Design and Structures Branch (CD-S), Engineering Division; the second phase was performed by Dr. Kraus, Ms. Rosati, and Ms. Kathryn J. Gingerich, Physical Scientist, Coastal Processes Branch (CR-P).

The dedicated professionals who assisted in the data collection under harsh environmental conditions of the surf zone are acknowledged. Key members, their affiliations at the time of the project, and their major function during data collection were: Dr. Lindsay Nakashima, Louisiana Geological Survey, sediment processing, surveying, experiment design; Messrs. Gary Howell and Ray Townsend, Prototype Measurement and Analysis Branch, CERC, current meter setup and current measurement; Ms. Jane M. Smith, Oceanography Branch (CR-O), current data collection and trap operator; Ms. Mary Cialone, CR-P, surveying, sediment processing, and trap operator; Dr. Shintaro Hotta, Tokyo Metropolitan University, Tokyo, Japan, photopole wave measurement team leader; Mr. Bruce Ebersole, CR-P, and Dr. Steven Hughes, CR-O, photopole camera operators and trap operators. Field assistants were: Drs. Hans Hanson and Magnus Larson, University of Lund, Sweden, Ms. Mary Sue Jablonsky, Virginia Institute of Marine Science, and Dr. Hyo Kang, Old Dominion

University. Additional field assistance was rendered by Messrs. Darryl Bishop and Edward Hands, CD-S, and Dr. Rao Vemulakonda, CR-P. Support personnel at the CERC Field Research Facility were: Mr. Curt Mason, Chief, Mr. William Birkemeier, Mr. Peter Howd, Ms. Harriet Klein, and Mr. Carl Miller.

This report benefitted from reviews by Dr. Hughes and Mr. Birkemeier. The study was performed under general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, CERC, respectively, and administrative supervision of Mr. H. Lee Butler, Chief, CR. This report was edited by Ms. Gilda F. Miller, Information Products Division, Information Technology Laboratory, WES.

Acting Commander and Director of WES during preparation of this report was LTC Jack R. Stephens, EN. Technical Director was Dr. Robert W. Whalin.

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CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters
inches	2.54	centimeters
pounds (mass)	0.4536	kilograms
pounds (force)	4.4480	newtons

DUCK85 SURF ZONE SAND TRANSPORT EXPERIMENT

PART I: INTRODUCTION

Background

1. This report describes procedures and results of a field experiment performed to measure the longshore sand transport rate in the surf zone as part of the DUCK85 field data collection project. The objective was to measure synoptically the longshore sand transport rate together with the environmental factors that produced and controlled the sand movement, including local waves, longshore current, water level, and beach bathymetry. Samples were retained to determine grain size distributions of the transported sand. The experiment was highly successful due to favorable wave and current conditions resulting in an extensive data set on the distributions of the longshore sand transport rate across the surf zone and through the water column.

2. This report is intended to provide complete documentation of the DUCK85 surf zone sand transport experiments, including a compilation of the data. Information is given on experiment equipment and methodology to allow critical examination of techniques used. Data given include transport rates, current speeds, wave heights and periods, beach profiles, grain size, water level, and arrangement of the experiments. Supplementary data on meteorology and offshore wave conditions are given, and reference is made to sources of more complete information.

Motivation

3. Estimates of the longshore sand transport rate are required in a multitude of projects involving shore protection, beach nourishment, and harbor and navigation channel maintenance. In addition, during the past decade considerable progress has been made in numerical modeling of nearshore waves, currents, and beach change. Beach morphology response models are moving from the research level to the practical level as engineering design

tools. A requirement in making this transition is improved capability for predicting the longshore sand transport rate, not only the total longshore transport rate but also its distribution across the surf zone and through the water column. For example, these distributions are needed for estimating bypassing around, over, and through groins and jetties, and behind detached breakwaters.

4. Presently available predictive formulas for the longshore sand transport rate are generally acknowledged as providing only a rough approximation of the actual rate. The number of accepted field measurements comprising the data base is surprisingly small considering the importance of the problem, and scatter in the data is great, reflecting randomness in the physical processes, limitations in measurement techniques, and simplifications in predictive expressions used to describe the fluid and sand motion. Presently employed predictive formulas for the transport rate do not incorporate dependencies on grain size, breaking wave type or wave-induced turbulence, properties of the waves or longshore current beyond mean values, or influence of the local bottom shape. The transport rate is expected to greatly depend on location in the surf zone, and its dependency on the local environmental conditions must be known to calculate cross-shore and vertical distributions.

5. Recognizing the need for making point measurements of the longshore sand transport rate to obtain cross-shore and vertical distributions, in 1985 the Surf Zone Sediment Transport Processes Research Work Unit, under the Shore Protection and Restoration Program at the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station, initiated a series of field experiments aimed at collecting comprehensive data sets on sand transport and processes responsible for the sand movement. Field data collection was planned for beaches composed of different materials ranging from fine sand to gravel and for wave climates ranging from small to large wave steepness. Measurements were planned for beaches with transport influenced by coastal engineering activities, such as near structures or beach fills, as well as on beaches that have not been disturbed by engineering activities. This report describes results of the first field data collection project in the planned series. The experiment was originally intended as a test of a newly developed sand trap and associated field data collection

procedures. However, the wave, current, and sand transport conditions proved to be ideal, and a large amount of data was collected.

Sand Transport Measurement Methods

6. Three methods were considered for measuring the transport rate at the DUCK85 field data collection project; sand tracers, impoundment at temporary or permanent obstructions, and traps. In preparation for DUCK85, Kraus (1987) surveyed available measurement methods and concluded that traps offered the best means to obtain transport rate data compatible with the accuracy and detail required by existing numerical models which simulate beach evolution. Traps were also determined to be the least expensive of the three methods, yielding the highest data-point-per-dollar ratio.

7. Portable traps allow measurement of the vertical distribution of the transport rate (i.e., transport at the bed and in the water column), and simultaneous deployment of traps at intervals across the surf zone enables measurement of the cross-shore distribution of the longshore transport rate. Traps measure the sand flux, a quantity directly related to the transport rate, and not simply a sediment concentration. As in concentration measurements, transported particles are automatically retained by the traps and made available for analysis. Traps collect the material that actually moves, including sand, shell fragments, and other particles of size nominally larger than the trap mesh, and no assumptions need be made about grain size, as required in tracer studies. Mean wave and current conditions in the surf zone typically change on the order of minutes, and traps are well suited to such a sampling interval as opposed to tracer and impoundment methods. Traps are also inexpensive to construct and maintain, and only a minimum amount of training is necessary to use them.

8. Traps have disadvantages, notably potential for scour and restriction to use in surf zones with significant breaking wave heights on the order of 1 m or less. A laboratory experiment program was initiated to examine the hydraulic efficiency (Rosati and Kraus 1988) and sand trapping efficiency (Rosati and Kraus in preparation) of the trap used in this field program to understand its characteristics and to optimize the design.

DUCK85 Field Data Collection Project

9. During September and October 1985, CERC hosted and participated in a major multidisciplinary and multi-institutional nearshore processes field data collection project called DUCK85 (Mason, Birkemeier, and Howd 1987). The name DUCK85 derives from the location of CERC's Field Research Facility (FRF), the site of the experiment, which is located near the village of Duck, North Carolina, on the Outer Banks barrier islands (Figure 1). More than 50 researchers from CERC, other Government agencies, universities, and organizations from overseas participated in DUCK85 to conduct a wide variety of nearshore process experiments as well as to evaluate and perfect newly developed instrumentation and measurement methods.

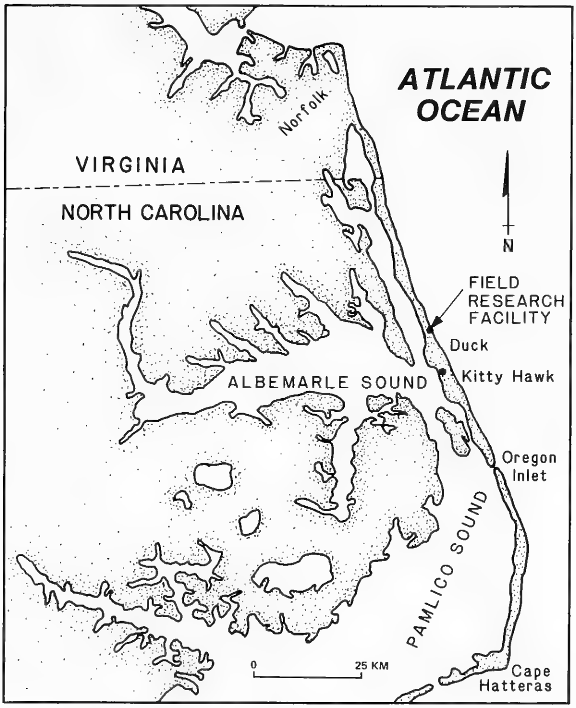


Figure 1. Location map for the FRF

10. The DUCK85 project consisted of two parts, a September phase which took advantage of relatively low wave heights to perform labor-intensive experiments in the surf zone, and an October phase which used primarily electronic instrumentation and remote sensing to measure storm-related nearshore processes. The surf zone sand transport experiments were performed in September as a self-contained program by CERC researchers with interest in measuring surf zone waves, currents, and sand transport.

11. The CERC surf zone data collection effort benefitted from the extended coverage provided by experiments performed concurrently by other research teams, yielding data on beach profiles, offshore waves and currents, and wind. Papers and reports describing results of DUCK85 experiments related to the work discussed here are: Howd and Birkemeier (1987), beach morphology change; Kraus and Dean (1987), preliminary results of the trap experiments; Ebersole and Hughes (1987), a companion data report listing the surf zone wave measurement method and results; Ebersole (1987) and Hughes and Borgman (1987), analyses of the surf zone wave data; Hubertz et al. (1987), a companion data report listing offshore wave and current measurements; Kraus and Nakashima (1987), measurement of currents and sand transport in a rip current; and Kraus, Gingerich, and Rosati (1988), revised values of the total transport rate and discussion of results from the follow-up field data collection project to DUCK85, called SUPERDUCK. Additional data are compiled in an FRF summary data report for September, 1985 (Field Research Facility 1985). The equipment and procedures used during the September-phase DUCK85 surf zone sand transport experiments, including wave and current measurements, are documented on a narrated 22-min video tape (Hughes and Kraus 1985).

Report Contents

12. An orientation to the study site and description of the experiment equipment, methodology, and analysis procedures are given in Part II. Selected results and properties of the data are presented in Part III, and a general evaluation of the field project is given in Part IV. Appendix A contains a listing of the data and explanatory discussion, and Appendix B lists the notation used in this report.

PART II: BACKGROUND OF THE EXPERIMENT

Experiment Site and Schedule

13. All essential equipment used in the surf zone experiments was transported from CERC to the FRF in a truck. Setup on the beach and equipment preparation and testing required approximately 1-1/2 days and took place over 3-4 September 1985. Main data collection was conducted over 5-9 September. Disassembly of the base camp, including cleaning and repacking of equipment, was done over 11-12 September.

14. Experiments were performed from a base camp established on the beach near the north property line of the FRF. Figure 2 is a plan-view sketch of the base camp, FRF coordinate system, and the general physical arrangement of the experiments. The area near the north property line was selected to avoid possible contamination of waves, currents, and nearshore topography in the vicinity of the experiments by the 600-m-long FRF pier located approximately 1,000 m to the south. An air-conditioned trailer located behind the dune line provided a protective environment for the data recorders and other sensitive instruments.

15. These labor-intensive experiments were performed under highly favorable sea conditions characterized by "clean" swell with moderate wave heights. Figure 3 shows the wave height and period for 3-11 September measured at FRF Gage 630, located in a depth of 18 m, and water level as recorded on a gage located at the end of the pier. During the 5 days of intensive data collection (5-9 September), the offshore wave conditions were relatively constant, with the spectrally based significant wave height, H_{mo}, in the range of approximately 0.4-0.5 m and the peak spectral period, T_p, in the range of approximately 9-12 sec. At the base camp, long-crested waves of cnoidal form were visually observed to arrive from slightly out of the southern quadrant, producing a longshore current moving to the north with a magnitude in the range of 0.1-0.3 m/sec. The wind was light (speed less than approximately 5 m/sec (Mason, Birkemeier, and Howd 1987)) and directed offshore. Table 1, adapted from Ebersole and Hughes (1987), summarizes the wind and offshore wave regime during the sand-trapping data collection period.

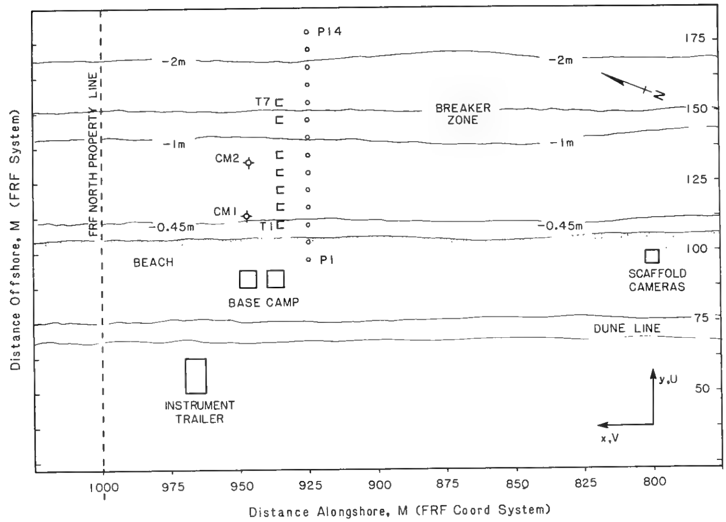


Figure 2. Base camp and typical arrangement of a sand-trapping experiment

The surf zone data collection group consisted of approximately 15 members; work was divided into four functional areas of sand trapping, current measurement, wave measurement, and beach profile surveying.

16. A small rip current is frequently located just north of the FRF property line. It was intended to use the southern longshore feeder current of the rip as a dependable source of a steady and unidirectional longshore current when the direction of the current generated by oblique wave incidence became confused. The longshore sand transport rates and the current moving the sand were produced by combined oblique wave incidence and the rip feeder current. In comparisons to theoretical expressions, it would be invalid to use predictive formulas for either the longshore current or the longshore sand transport rate that are solely functions of parameters related to obliquely incident waves.

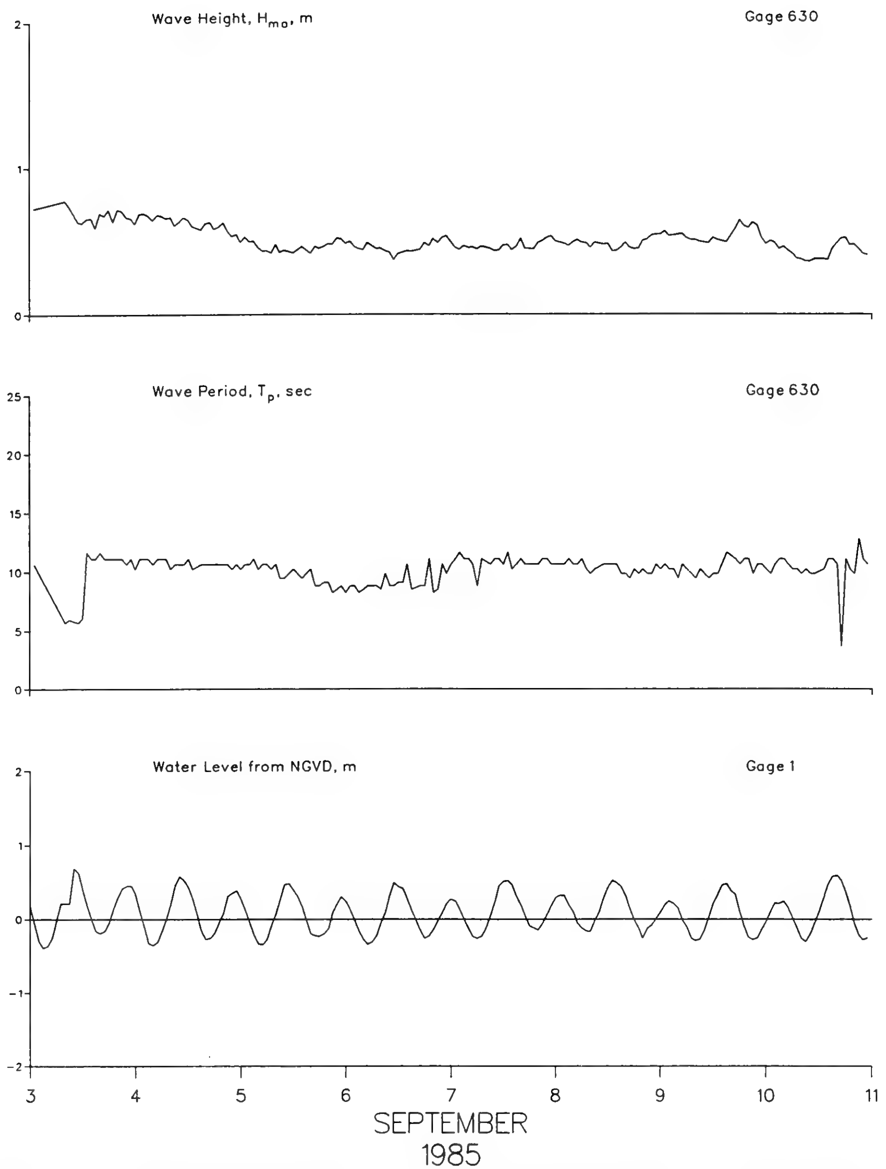


Figure 3. Wave height and period measured 6 km offshore in 18 m of water, and water level recorded at the seaward end of the pier

Table 1

Summary of Wind and Offshore Wave Conditions

Date	Time (EDST)*	Wind Speed m/sec	Wind Direction deg, TN**	H_{mo} m	T_p sec
3 Sep	0200	6	233	0.70	10.9
	0800	4	241	0.78	12.0
	1400	3	209	0.65	12.0
	2000	3	173	0.64	11.3
4 Sep	0200	5	235	0.69	12.0
	0800	4	242	0.66	11.3
	1400	6	231	0.60	11.3
	2000	3	195	0.61	10.0
5 Sep	0200	6	235	0.53	11.3
	0800	6	250	0.43	11.3
	1400	6	238	0.45	11.3
	2000	4	200	0.47	9.1
6 Sep	0200	7	233	0.50	9.1
	0800	7	246	0.45	9.1
	1400	7	243	0.43	12.0
	2000	3	214	0.47	11.3
7 Sep	0200	6	243	0.46	12.0
	0800	4	267	0.47	12.0
	1400	3	26	0.47	12.0
	2000	1	113	0.45	12.0
8 Sep	0200	0	---	0.49	11.3
	0800	2	249	0.49	10.0
	1400	4	117	0.43	9.5
	2000	4	192	0.45	10.0
9 Sep	0200	5	241	0.56	11.3
	0800	4	237	0.51	10.6
	1400	5	230	0.51	10.6
	2000	5	189	0.61	9.5
10 Sep	0200	7	227	0.49	10.0
	0800	5	234	0.39	10.6
	1400	4	234	0.39	10.6
	2000	5	193	0.47	11.3

* EDST: Eastern Daylight Savings Time

** TN: True North (shoreline orientation N20°W)

Experiment Arrangement and Measurement Techniques

Surf zone waves and water level

17. The wave height distribution across the surf zone was measured by filming the water surface elevation at 14 target poles made of steel pipe (numbered P1 to P14 in Figure 2) jetted into the sea bottom on a line crossing the surf zone. The poles were spaced at nominal 20-ft (6-m) intervals and painted a fluorescent yellow color to facilitate reading of the films. These poles, called "photopoles" by CERC researchers, each had two short rods placed horizontally near their top ends and separated by a known distance to calibrate the wave height measurement. Figure 4 shows the photopole line during DUCK85. Pairs of photopoles were filmed with six synchronized 16-mm professional-grade movie cameras mounted on a 4.5-m-high scaffold located on the beach about 125 m to the south of the photopole line. The cameras were run in the pulse mode at 5 Hz for a nominal duration of 12.5 min which included a sand trap run. Ebersole and Hughes (1987) describe the DUCK85 photopole experiments and results.

Figure 4. Photopole line spanning the surf zone

18. The bottom profile along the photopole line was surveyed each day by means of an infrared beam total survey station housed at the main building of the FRF (cf Table A5 of Appendix A for the profile survey data). These surveys were supplemented by standard transit surveys performed from the base camp and by wide-area surveys taken by the CERC Coastal Research Amphibious Buggy (CRAB). Howd and Birkemeier (1987) and Ebersole and Hughes (1987) present wide-area bathymetry data. The nearshore bathymetry in the vicinity of the base camp remained predominantly two-dimensional during the trap experiments. The foreshore had a steep slope covered by pebbles for approximately 5 m, and relatively high waves (20-50 cm) frequently broke directly upon it. Since there was no sand surface on the step and the pebbles did not appear to move alongshore, traps were not placed on the step. Seaward of the step, the profile fell steeply then rose to either a bar or a plateau that extended across much of the surf zone. The surf zone bottom seaward of the step consisted of a fine-grained sand substrate with a median grain size of 0.17 mm.

19. The mean water level was obtained at 6-min intervals from a tide gage located at the seaward end of the FRF pier (Table A4, Appendix A). Water levels are referenced to the National Geodetic Vertical Datum (NGVD), which is related to the mean sea level datum (MSL) by MSL(m) = NGVD(m) + 0.067. The maximum tidal variation observed during the experiment was approximately 1 m (Figure 3). Local mean water levels across the surf zone are tabulated in Ebersole and Hughes (1987) for individual experiment runs.

Surf zone currents

20. Water flow was measured with two 2-component Model 551 Marsh-McBirney electromagnetic current meters. The meters were mounted on newly designed tripods and connected to shore by cable to recorders located in the instrument trailer. The tripods, shown in Figure 5, are made of 1.9-cm (3/4-in.) stainless steel and stand approximately 1.5 m high. The lower ends of the tripod legs were sunk into the bed to a depth of about 10 cm by shaking the tripod back and forth and applying downward pressure. A tripod with current meter attached was easily moved by two individuals, permitting its rapid relocation in the surf zone in response to varying tide level, wave

Figure 5. Current meter mount with meter installed

conditions, and current characteristics. An adjustable collar on the tripod holds the metal cylinder housing the meter electronics and preamplifier, allowing vertical adjustment of the current meter sensor. The flow meter sensor was placed 20-30 cm above the bed in all deployments. The horizontal axis of the current meter was aligned with its y-component parallel to the trend of the shoreline. The current meters sampled at 4 Hz and typically recorded for a nominal 30-min period which included the sand-trapping run.

Sand transport rate

21. The longshore sand transport rate was measured by means of portable traps such as shown in Figure 6. The sand collection element of the trap consisted of a metal frame or nozzle to which a cylindrical bag of flexible filter cloth called a "streamer" was attached. The polyester monofilament cloth allowed water to pass through but retained sediment of nominal diameter greater than the 0.105-mm mesh, which encompasses sand in the fine grain size region and greater. The concept of the streamer-type trapping device for use in the nearshore was introduced by Katori (1982, 1983). Development of the trap has continued at CERC, including mounting of the streamers on various

Figure 6. Streamer traps used at DUCK85

types of racks (Kraus 1987), and optimization of the trap nozzle geometry (Rosati and Kraus 1988, Rosati and Kraus in preparation). Streamer nozzles were mounted vertically on stainless steel racks and pointed into the direction of flow so that they were located forward of the racks and any scour clouds produced by the rack and trap operator. Visual observation during operation indicated that scoured sand at the rack did not move upstream and into the streamers. Data collection was always performed in a unidirectional current so that the streamer never reversed direction, a situation which might cause collected sand to be lost.

22. The nozzles on the traps used at DUCK85 were made of 1/4-in. stainless steel bar and had a width of 15 cm and height of 9 cm (Figure 7). Nozzles were attached to the trap racks by mounting bars and secured in place by plates with wing nuts. Figure 8 gives a schematic of the complete trap, with only one streamer shown for clarity. Typically, five streamers were mounted on the racks.

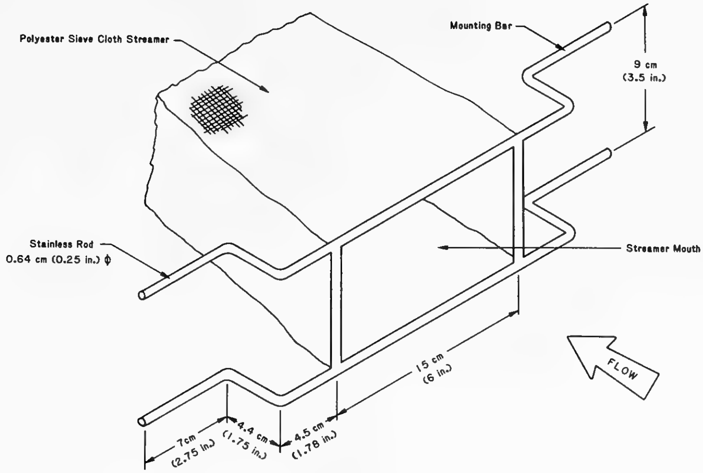


Figure 7. DUCK85 streamer nozzle

23. Based on the results of a uniform-flow tank experiment conducted following the field project (Rosati and Kraus 1988), the streamer trap nozzle used at DUCK85 is no longer recommended. This test examined the hydraulic efficiencies of 22 generic nozzle configurations plus several variations and led to an improved design that has been used in later field data collection projects such as SUPERDUCK.

24. In addition, sand-trapping efficiency tests in uniform flow were performed in another series of experiments (Rosati and Kraus in preparation) for a small number of nozzle configurations which had near optimal hydraulic efficiencies, including the DUCK85 nozzle. It was found that the DUCK85 nozzle had a sand-trapping efficiency near unity (0.92) for suspended sand, but a much lower efficiency for a nozzle resting on the bed (0.13). The small value (0.13) of the bed-load trapping efficiency (which includes suspended load within 9 cm of the bottom) is caused by scour and the scour hole created under the nozzle, allowing sediment to pass under it. Other nozzle designs, which replace the 1/4-in. rods with sheet metal hoods essentially eliminate this problem for uniform flow conditions. The actual efficiency of the

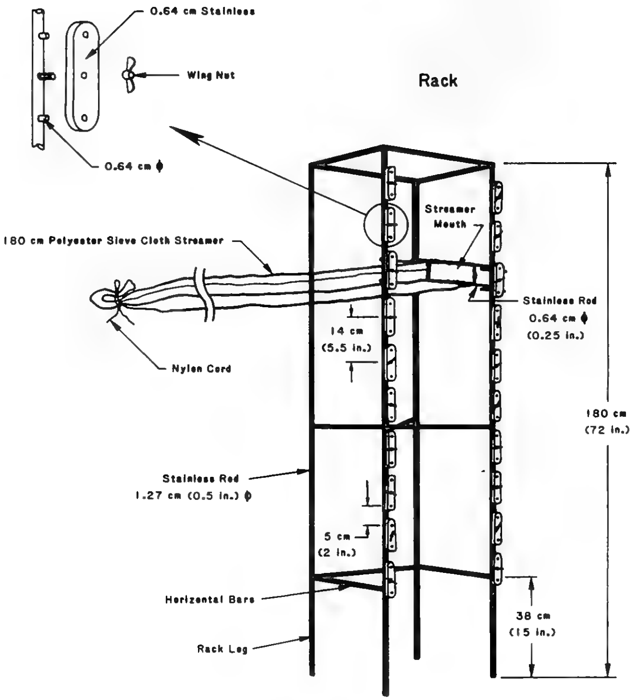


Figure 8. Schematic of the streamer trap rack

streamer trap in intersecting oscillatory and quasi-steady uniform flow in the surf zone is not known, but qualitative observation in the field indicates that surf zone efficiencies may be approximated by efficiencies determined in the uniform flow tank under sheet flow conditions.

25. To measure the transport rate, the traps (denoted by symbols T1 to T7 in Figure 2) were carried to predetermined positions defined by reference to the photopole line and an additional line of survey marker poles placed parallel to the photopole line. Typically, one person carried and operated one trap; however, two operators were sometimes necessary near the breaker line. At a signal, the racks were simultaneously thrust into the bed with the

nozzles oriented into the longshore current. Horizontal bars along the bottom of three sides of the rack could be stepped on to bury the 38-cm-long legs. At complete burial, the horizontal bars prevented further penetration of the legs into the bed and kept the lower-most streamer nozzle at the bed. During the course of a deployment (typically of 5- to 10-min duration), the trap operator would periodically step on the horizontal bars to keep the legs fully buried and to counter wave and current action, which would tend to tilt the trap shoreward and downstream, respectively. In weak longshore currents, the streamers would wrap around the vertical bars of the rack with passage of waves, requiring the trap operator to untangle them. In moderate to strong currents (greater than approximately 20 cm/sec), the streamers would fully extend in the flow and require little attention from the trap operator. In fact, during measurement of the sand transport rate in the strong offshore-directed current in the throat of a rip current, the streamers extended fully seaward, against the incident waves, without tangling on the rack or reversing direction. Figure 9 shows the traps being deployed.

26. At the end of the sampling period, a signal was given from the beach and the traps were pulled from the bed, lifted above the water, and brought to shore (Figure 10). Collected sand was washed from the streamers with seawater onto small patches of filter cloth. The sand sample and cloth (of known weight when wet) were weighed in the drip-free condition (Kraus and Nakashima 1986). Samples from one run per day (all traps) were retained for drying and grain size analysis in the laboratory. The dry weights obtained allowed calibration of the drip-free to dry weight conversion factor.

27. In between experiment runs and in the evening at the end of each experiment day, the trapped sand weights were inspected and plotted to understand qualitative aspects of the transport conditions and to design the next series of runs, such as placement of traps. For example, at first it was thought that there would be enhanced transport in the vicinity of the bar and trough near the step, and it was initially planned to place traps at closer intervals in this area. Since this proved not to be the case by inspection of the trapped sand weights, a more uniform cross-shore placement of traps was implemented. The capability to analyze the transport rate data on site is considered one of the important advantages of using traps, enabling a quality

Figure 9. Streamer traps deployed in a cross-shore run

Figure 10. Traps being removed from the surf zone

control check on trap operation and early interpretation of results for further experiment design.

Transport Rate Analysis

28. The procedures for calculating transport rates from the raw data are described in this section. As opposed to instantaneous samplers, pumps, and acoustic or optical sensors which measure sand concentration, the streamers measure a sand flux, i.e., the weight of sand passing through the nozzle of a certain cross-sectional area in the sampling interval. If the sampling is performed in a unidirectional flow, as was the case in these experiments, no sand is lost once it has entered the streamer, and the flux can be directly associated with the current to develop predictive empirical relations. The raw data of sand weight collected in the streamers are listed in Table A1 of Appendix A.

29. The flux of sand F at streamer k is given by:

$$F(k) = \frac{S(k)}{\Delta h \Delta w \Delta t} \tag{1}$$

in which

F = sand flux ($kg/(m^2\text{-sec})$)

k = streamer number, increasing in order from the bottom ($k = 1$) to the last streamer ($k = N$)

S = dry weight of sand (kg)

Δh = height of streamer nozzle (0.09 m for DUCK85)

Δw = width of streamer nozzle (0.15 m for DUCK85)

Δt = sampling time interval (sec)

The flux between adjacent streamers, $FE(k)$, can be estimated by linear interpolation using adjacent measured values:

$$FE(k) = 0.5[F(k) + F(k+1)] \tag{2}$$

30. The total transport rate per unit width i at a particular trap is calculated by using the determined fluxes and distances $\Delta a(k)$ between nozzles:

$$i = \Delta h \sum_{k=1}^{N} F(k) + \sum_{k=1}^{N-1} \Delta a(k) FE(k) \qquad (3)$$

in which N is the total number of streamers on the trap. The first summation term represents the actual measured fluxes and the second summation term represents the interpolated fluxes between nozzles. If traps were placed on a line across the surf zone, transport rates per unit width were calculated with Equation 3, and the trapezoid rule was used to compute the total longshore sand transport rate across the surf zone. Elevations of the streamers above the bed are listed in Table A1 of Appendix A, and locations of the traps in the surf zone are given in Table A2.

PART III: EXAMPLE RESULTS

31. This chapter lists and explains the principal data on transport rates, currents, and waves obtained in the September phase surf zone experiments at DUCK85. Selected results are also presented to introduce the properties and potential uses of the data set.

Orientation to the Measurement Runs

32. Three types of sand transport rate data collection runs were performed using the traps:

a. Measurement of the cross-shore distribution of the longshore sand transport rate.

b. Measurement of transport rates at neighboring locations, called "consistency tests."

c. Measurement of the transport rate in a rip current.

If several streamers were mounted on the racks, as was usually the case, each type of measurement also provided the vertical distribution of the sand flux.

33. Sand transport rate runs documented in this report are listed in Table 2. Each run is assigned a number, as shown in the first column, which uniquely identifies it by the date and time the sampling was conducted. The concatenation of numbers comprising a run ID gives the year (85), month (9), day (4,5,6, or 9), and start time of the run in Eastern Daylight Savings Time (EDST) as hours and minutes on a 24-hr clock. Current velocity and wave measurement (photopole) ID numbers are similarly defined. The current meters and movie cameras were often started a minute or two earlier than the corresponding sand trap run.

Cross-shore distributions

34. Emphasis was placed on measurement of the distribution of the longshore transport rate across the surf zone. In measuring cross-shore distributions, the vertical distribution of the sand flux was also obtained at each trap. Ten runs were performed to measure the cross-shore distribution. Complete wave and current data are presently available for the eight runs performed over 5-6 September.

Table 2

Summary of DUCK85 Surf Zone Sand Trap Data and Tide

Run ID No.	Time (EDST)	Data Collection	No. Traps	Tide
		4 Sep 88		
859041515	15:15-15:20	Consistency	2 pairs	Falling
		5 Sep 88		
859050957	09:57-10:02	Cross-shore	7	Rising
859051057	10:57-11:02	Cross-shore	7	Rising
859051352	13:52-14:02	Cross-shore	6	High
859051528	15:28-15:38	Cross-shore	7	Falling
		6 Sep 88		
859060916	09:16-09:26	Cross-shore	7	Rising
859061018	10:18-10:28	Cross-shore	7	Rising
859061303	13:03-13:13	Cross-shore	7	High
859061400	14:00-14:10	Cross-shore	7	Falling
		7 Sep 88		
859070922	09:22-09:32	Consistency	1 pair	Low
859071000	10:00-10:10	Cross-shore	6	Rising
859071110	11:10-11:20	Cross-shore	6	Rising
859071324	13:24-13:34	Consistency	1 pair	High
		9 Sep 88		
859090804	08:04-08:14	Rip current	7	Falling
85909-AM1	a.m., 10 min	Consistency	1 pair	Low
85909-AM2	a.m., 10 min	Consistency	1 pair	Low
85909-AM3	a.m., 10 min	Consistency	1 pair	Rising
85909-AM4	a.m., 10 min	Consistency	1 pair	Rising
85909-AM5	a.m., 10 min	Consistency	1 pair	Rising
85909-AM6	a.m., 10 min	Consistency	1 pair	Rising

Consistency tests

35. Consistency tests were devised to compare collected quantities of sand from traps placed in close proximity. Since the traps had not yet undergone testing in the laboratory, it was necessary to obtain some indication of the reliability and reproducibility of results. In the consistency tests, two traps were placed in the surf zone approximately 1 m apart. The seaward trap was located a distance sufficiently downdrift of the shoreward

trap (typically, about 1 m) so that sand scoured from the seaward trap and transported shoreward with the incoming waves would not be collected by the shoreward trap. Waves and currents were not measured during consistency tests. The consistency tests performed on 9 September were made in the south longshore feeder current of a rip current.

Rip current measurement

36. An experiment was performed on 9 September, the final day of data collection, with the objective of measuring the water flow and sand transport in the rip current located just north of the FRF property line. Two traps each were placed in the north and south longshore feeder currents of the rip, and three traps were placed in the throat of the rip. Streamers on traps placed in the strong offshore current flow in the rip throat extended seaward, directly against the incident waves. The experiment showed that the amount of sand entering the rip from alongshore was approximately equal to that leaving seaward in the throat (Kraus and Nakashima 1987). Sampling in the rip current can be seen on the DUCK85 video (Hughes and Kraus 1985).

Currents

37. The two current meters were placed at representative locations along a line crossing the surf zone just north of the photopole line. The meters were moved as necessary if the surf zone width changed with the tide. Positions of current meters are listed in Table A3 of Appendix A. The basic processed current speed data are given in Table 3 for nine runs. The run ID number for the current meter records have a "dot extension" which identifies the current meter component (C) as the x- or y-component, and the meter as number 1 or 2. The x-axis points offshore (positive x-component indicates seaward-directed flow), and the y-axis points north. Current meter 1 was located shoreward of current meter 2.

38. In Table 3, current speeds are given to the tenth of a centimeter per second to reduce roundoff error in analysis; the meters probably do not measure with that accuracy. The mean current speed, standard deviation, and maximum and minimum current speeds listed in columns three through six, respectively, were calculated for the indicated trap sampling interval. The mean over the trapping interval can be compared to the mean speed for the

Table 3

Summary of Current Velocity Measurements

Run ID No.	Trap Interval min	Sampling Mean cm/sec	Standard Deviation cm/sec	Maximum cm/sec	Minimum cm/sec	Total Record Length min	Total Record Mean cm/sec
859050957.CX1	5	6.6	35.7	77.4	-85.4	36.6	3.8
.CY1	"	13.4	10.5	41.7	-26.5	"	4.9
.CX2	"	3.7	43.1	84.5	-110.3	"	-2.8
.CY2	"	8.1	15.7	46.9	-60.0	"	8.0
859051057.CX1	10	9.7	35.2	99.0	-122.0	35.2	8.5
.CY1	"	16.9	13.5	64.1	-24.4	"	13.5
.CX2	"	6.8	41.7	111.8	-139.3	"	7.8
.CY2	"	17.7	14.6	59.5	-24.6	"	5.4
859051352.CX1	10	7.5	35.2	95.1	-101.4	30.1	6.5
.CY1	"	14.3	15.5	63.0	-30.8	"	9.8
.CX2	"	3.0	41.8	108.3	-123.2	"	2.6
.CY2	"	19.1	15.6	69.5	-38.0	"	14.6
859051528.CX1	10	0.0	32.0	70.4	-83.2	29.9	-0.6
.CY1	"	18.8	19.0	77.5	-35.1	"	23.1
.CX2	"	0.2	44.6	97.3	-144.7	"	-4.6
.CY2	"	25.5	22.2	91.7	-56.7	"	28.0
859060916.CX1	10	4.1	24.4	62.1	-70.2	30.4	4.7
.CY1	"	27.8	16.9	82.2	-9.1	"	27.0
.CX2	"	-2.1	41.6	113.6	-142.0	"	-1.6
.CY2	"	33.1	22.1	125.9	-23.8	"	32.3
859061018.CX1	10	7.3	28.0	72.8	-86.2	29.3	7.3
.CY1	"	28.3	12.8	71.1	-7.7	"	25.4
.CX2	"	3.3	39.8	108.3	-122.5	"	-0.1
.CY2	"	30.0	16.9	81.6	-16.1	"	27.6
859061303.CX1	10	8.8	32.2	89.1	-108.2	28.8	8.5
.CY1	"	23.0	16.1	77.4	-21.0	"	19.1
.CX2	"	8.0	33.7	91.1	-128.1	"	5.2
.CY2	"	21.2	11.9	54.0	-21.9	"	16.9
859061400.CX1	10	7.8	35.8	86.9	-100.5	30.1	6.8
.CY1	"	17.9	15.9	64.7	-28.4	"	20.3
.CX2	"	-0.8	33.2	95.0	-148.8	"	-1.0
.CY2	"	17.4	16.1	67.1	-35.1	"	19.9
859090804.CX1	10	39.2	32.6	122.6	-84.8	40.0	30.4
.CY1	"	16.9	26.2	72.3	-60.3	"	20.1
.CX2	"	-0.7	25.8	70.7	-85.1	"	-1.3
.CY2	"	22.0	19.5	74.4	-38.4	"	19.9

total record, given in the last column. Typically, the two means differ substantially, indicating that it is important to use values of forcing functions pertaining to the exact time of the sand transport rate measurement. Most x-components of the mean current are positive, indicating that the flow was directed offshore at an elevation of approximately 20 cm from the bed where the current meter sensors were located. In general, the cross-shore flow was relatively weak. The standard deviations of the flow and magnitudes of the maximum and minimum speed are much greater for the cross-shore flow than for the longshore flow, as expected. Although the longshore (y-component) currents had substantial minima (negative values), these were manifested as sharp peaks in records that otherwise showed consistent trends for unidirectional flow to the north. In fact, the streamers were never observed to reverse direction during the runs.

Waves and Water Levels

39. The analysis procedure for obtaining wave and water level parameters from the photopole record is described in detail by Ebersole and Hughes (1987). In summary, the digitized time series were cleaned through visual inspection and then filtered to remove long-period wave motions. The filter eliminated oscillations with periods greater than 30 sec and preserved oscillations with periods less than 16 sec. Various statistical properties of the approximately 12-min long filtered record were then determined, as listed in Table 4. For each experiment run, the landward-most pole is at the top of the group, and the seaward-most pole is at the bottom. The listed wave properties were calculated through both spectral and individual wave (zero-up crossing and zero-down crossing) methods.

40. The notation used in Table 4 denotes quantities as follows:

BED ELEV	--	seabed elevation relative to NGVD (meters)
ELEV mean	--	mean water surface elevation measured during the run at the photopole, either above (+) or below (-) NGVD (meters)

TOTAL DEPTH	--	total mean water depth equal to the sum of the seabed elevation (below NGVD) and the mean water surface elevation (meters)
ELEV max	--	maximum water surface elevation relative to the mean (meters)
ELEV min	--	minimum water surface elevation relative to the mean (meters)
ELEV skewness	--	skewness of the water surface elevations relative to the mean
ELEV kurtosis	--	kurtosis of the water surface elevations relative to the mean
H_{mo}	--	energy-based significant wave height computed as four times the square root of the area under the energy density spectrum, as determined from the high-passed water surface elevation time series (meters)
T_p	--	peak spectral period, computed from the central frequency associated with the spectral band containing the greatest energy density (sec)
Waves UP	--	number of primary, individual waves identified using the zero-upcrossing method
Waves DOWN	--	number of primary, individual waves identified using the zero-downcrossing method
Havg UP	--	average wave height using upcrossing results (meters)
Havg DOWN	--	average wave height using downcrossing results (meters)
Tavg UP	--	average wave period using upcrossing results (sec)
Tavg DOWN	--	average wave period using downcrossing results (sec)
Hrms UP	--	root-mean-squared wave height using upcrossing results (meters)
Hrms DOWN	--	root-mean-squared wave height using downcrossing results (meters)
H1/3 UP	--	average of the highest one-third wave heights using upcrossing results (meters)

H1/3 DOWN	--	average of the highest one-third wave heights using down-crossing results (meters)
H1/10 UP	--	average of the highest one-tenth wave heights using up-crossing results (meters)
H1/10 DOWN	--	average of the highest one-tenth wave heights using down-crossing results (meters)
Hmax UP	--	maximum wave height using upcrossing results (meters)
Hmax DOWN	--	maximum wave height using downcrossing results (meters)

41. The mean water surface elevation measurements (relative to NGVD) include the effects of both tide and wave setup. The tidally induced mean elevation is assumed to be constant across the surf zone; therefore, the variation in the mean can be assumed to represent changes resulting from the incident wave field.

42. The average breaking wave height during a particular run can be determined from Table 4 as corresponding to the photopole having a maximum wave height statistic, for example, the maximum root-mean-square wave height. The location of the average breaking waves is then known to within an interval of plus or minus half the nominal distance between photopoles (± 3 m). During the runs, visual estimates were also made of the average position of the breakers; good agreement was found between the visual estimates and the position inferred from the photopole record.

Table 4

Summary of Wave and Water Level Parameters

RUN ID	BED ELEV m	ELEV mean m	TOTAL DEPTH m	ELEV max m	ELEV min m	ELEV skewness	ELEV kurtosis	Hmo m	Tp sec	WAVES UP	WAVES DOWN	Havg UP m	Havg DOWN m	Tavg UP sec	Tavg DOWN sec	Hrms UP m	Hrms DOWN m	H1/3 UP m	H1/3 DOWN m	H1/10 UP m	H1/10 DOWN m	Hmax UP m	Hmax DOWN m
859050955.A03	-0.46	0.293	0.75	0.45	-0.25	0.776	5.48	0.34	11.4	62	69	0.35	0.38	10.9	10.0	0.37	0.39	0.48	0.49	0.56	0.57	0.64	0.64
859050955.A04	-0.56	0.284	0.84	0.50	-0.21	1.241	4.67	0.43	11.4	65	66	0.43	0.44	10.3	10.2	0.44	0.45	0.54	0.52	0.60	0.58	0.65	0.68
859050955.A05	-0.49	0.278	0.77	0.62	-0.33	0.500	3.18	0.54	11.4	60	63	0.49	0.49	11.5	10.7	0.51	0.50	0.64	0.61	0.75	0.71	0.80	0.79
859050955.A06	-0.51	0.307	0.80	0.68	-0.29	0.826	4.75	0.51	13.1	65	65	0.52	0.51	10.4	10.4	0.54	0.54	0.70	0.67	0.80	0.75	0.93	0.85
859050955.A07	-0.52	0.289	0.81	1.12	-0.33	1.528	7.02	0.60	11.4	68	69	0.57	0.58	10.0	10.0	0.62	0.61	0.83	0.81	0.98	0.97	1.36	1.39
859050955.A08	-0.64	0.287	0.93	1.28	-0.41	1.565	6.79	0.79	11.4	72	69	0.66	0.68	9.3	9.8	0.73	0.76	1.02	1.03	1.21	1.26	1.42	1.58
859050955.A09	-0.80	0.323	1.12	1.32	-0.37	1.815	8.46	0.76	11.4	72	71	0.64	0.65	9.5	9.6	0.73	0.74	1.05	1.06	1.29	1.29	1.56	1.57
859050955.A11	-1.16	0.284	1.44	0.83	-0.37	1.357	5.66	0.70	11.4	63	65	0.57	0.57	10.8	10.5	0.63	0.62	0.87	0.87	1.03	1.04	1.11	1.15
859050955.A12	-1.32	0.262	1.58	0.82	-0.28	1.091	4.67	0.65	11.4	64	65	0.53	0.52	10.6	10.5	0.56	0.57	0.76	0.78	0.93	0.92	1.09	1.06
859050955.A13	-1.55	0.256	1.81	0.68	-0.31	1.002	4.29	0.61	11.4	67	64	0.46	0.47	10.2	10.6	0.50	0.51	0.68	0.70	0.80	0.83	0.89	0.87
859050955.A14	-1.88	0.259	2.14	0.59	-0.30	0.936	3.89	0.61	11.4	65	64	0.47	0.49	10.5	10.7	0.50	0.52	0.68	0.71	0.78	0.81	0.82	0.88
859051055.A03	-0.46	0.513	0.97	0.64	-0.23	1.693	8.74	0.37	15.3	65	70	0.39	0.39	10.1	9.6	0.41	0.42	0.55	0.55	0.69	0.68	0.82	0.78
859051055.A04	-0.56	0.511	1.07	0.67	-0.24	1.413	5.54	0.48	11.2	66	67	0.46	0.47	10.2	10.0	0.49	0.50	0.61	0.63	0.72	0.74	0.80	0.82
859051055.A05	-0.49	0.510	1.00	0.72	-0.28	0.825	3.92	0.59	11.2	68	68	0.52	0.53	9.9	9.9	0.56	0.56	0.73	0.73	0.83	0.82	0.93	0.87
859051055.A06	-0.51	0.495	1.01	0.76	-0.36	1.018	5.32	0.56	15.3	64	65	0.54	0.56	10.3	10.3	0.58	0.60	0.78	0.78	0.88	0.91	0.93	0.96
859051055.A07	-0.52	0.505	1.03	0.94	-0.25	1.930	8.64	0.69	11.2	70	70	0.55	0.55	9.6	9.6	0.61	0.62	0.86	0.87	0.98	0.99	1.14	1.16
859051055.A08	-0.64	0.502	1.14	1.10	-0.36	1.494	7.65	0.67	11.2	66	66	0.59	0.61	10.1	10.1	0.66	0.68	0.92	0.97	1.22	1.24	1.44	1.45
859051055.A09	-0.80	0.493	1.29	1.13	-0.39	1.462	8.90	0.55	11.2	68	68	0.48	0.48	9.8	9.8	0.55	0.56	0.76	0.79	1.14	1.16	1.47	1.51
859051055.A10	-0.89	0.369	1.26	0.89	-0.32	1.337	6.84	0.51	10.0	64	69	0.44	0.43	10.4	9.7	0.47	0.47	0.62	0.64	0.81	0.88	1.12	1.21
859051055.A11	-1.16	0.488	1.65	0.93	-0.28	1.274	6.58	0.53	11.2	61	62	0.45	0.44	11.0	10.8	0.50	0.48	0.66	0.64	0.91	0.87	1.15	1.18
859051055.A12	-1.32	0.477	1.80	0.83	-0.32	1.022	5.76	0.50	11.3	61	63	0.42	0.42	10.8	10.6	0.46	0.46	0.61	0.61	0.82	0.84	1.11	1.15
859051352.A03	-0.46	0.370	0.83	0.52	-0.24	0.616	5.05	0.36	12.6	49	62	0.36	0.40	13.2	10.4	0.37	0.41	0.47	0.50	0.53	0.56	0.58	0.64
859051352.A04	-0.56	0.381	0.94	0.49	-0.21	1.307	4.56	0.44	10.9	60	61	0.45	0.45	10.8	10.6	0.46	0.46	0.53	0.53	0.58	0.57	0.65	0.62
859051352.A05	-0.49	0.375	0.87	0.61	-0.27	0.477	2.66	0.56	12.6	63	62	0.49	0.49	10.3	10.5	0.51	0.50	0.62	0.60	0.69	0.66	0.74	0.73
859051352.A06	-0.51	0.374	0.88	0.72	-0.33	0.702	4.00	0.56	12.6	64	61	0.52	0.55	10.1	10.6	0.55	0.58	0.70	0.70	0.80	0.81	0.90	0.97
859051352.A07	-0.52	0.355	0.88	1.22	-0.28	1.817	7.87	0.69	10.9	66	68	0.65	0.64	9.8	9.6	0.70	0.70	0.95	0.93	1.12	1.11	1.40	1.42
859051352.A08	-0.64	0.356	1.00	1.32	-0.38	1.711	7.76	0.83	12.6	64	64	0.76	0.78	10.1	10.1	0.84	0.86	1.16	1.19	1.39	1.40	1.60	1.70
859051352.A09	-0.80	0.341	1.14	1.06	-0.32	1.631	7.47	0.72	12.6	66	68	0.63	0.64	9.7	9.6	0.70	0.72	1.00	1.03	1.21	1.21	1.32	1.32
859051352.A10	-0.89	0.382	1.27	1.47	-0.38	1.932	9.43	0.79	10.9	69	72	0.63	0.61	9.4	9.1	0.71	0.71	1.02	1.03	1.38	1.38	1.75	1.79
859051352.A11	-1.16	0.340	1.50	1.10	-0.37	1.633	7.14	0.78	10.9	62	64	0.62	0.63	10.5	10.1	0.71	0.72	1.05	1.06	1.25	1.24	1.43	1.47
859051352.A12	-1.32	0.313	1.63	0.81	-0.42	1.089	4.52	0.71	10.9	59	60	0.58	0.59	11.0	10.8	0.63	0.63	0.88	0.87	1.03	1.03	1.23	1.16
859051352.A13	-1.55	0.321	1.87	0.79	-0.31	1.021	4.46	0.66	10.9	60	60	0.54	0.55	10.9	10.9	0.58	0.59	0.78	0.80	0.93	0.95	1.06	1.05
859051352.A14	-1.88	0.308	2.19	0.80	-0.40	0.988	4.46	0.64	10.9	62	64	0.49	0.48	10.4	10.2	0.54	0.53	0.73	0.74	0.91	0.92	1.20	1.11

(Continued)

(Sheet 1 of 3)

Table 4 (Continued)

RUN ID	BED ELEV m	ELEV mean m	TOTAL DEPTH m	ELEV max m	ELEV min m	ELEV skewness	ELEV kurtosis	Hmo m	Tp sec	WAVES UP	WAVES DOWN	Havg UP m	Havg DOWN m	Tavg UP sec	Tavg DOWN sec	Hrms UP m	Hrms DOWN m	H1/3 UP m	H1/3 DOWN m	H1/10 UP m	H1/10 DOWN m	Hmax UP m	Hmax DOWN m
859051525.A03	-0.46	0.129	0.59	0.28	-0.21	0.027	2.86	0.30	12.8	54	55	0.29	0.30	12.2	11.9	0.30	0.31	0.37	0.37	0.44	0.42	0.47	0.43
859051525.A04	-0.56	0.108	0.67	0.39	-0.18	1.145	5.08	0.28	11.1	58	64	0.28	0.29	11.4	10.4	0.30	0.30	0.37	0.38	0.45	0.43	0.53	0.47
859051525.A05	-0.49	0.097	0.59	0.58	-0.23	0.507	3.11	0.44	12.8	55	57	0.40	0.41	12.0	11.7	0.41	0.42	0.52	0.50	0.61	0.61	0.71	0.77
859051525.A06	-0.51	0.077	0.59	0.53	-0.29	0.592	3.68	0.45	12.8	60	63	0.41	0.45	10.9	10.6	0.44	0.46	0.58	0.58	0.70	0.65	0.77	0.68
859051525.A07	-0.52	0.096	0.62	0.57	-0.29	0.830	3.72	0.51	11.1	61	65	0.47	0.47	10.8	10.2	0.49	0.49	0.61	0.62	0.68	0.70	0.81	0.79
859051525.A08	-0.64	0.079	0.72	0.66	-0.38	0.909	4.06	0.60	12.8	64	63	0.56	0.57	10.4	10.4	0.59	0.60	0.77	0.75	0.89	0.84	1.02	0.91
859051525.A09	-0.80	0.085	0.89	0.89	-0.32	1.623	7.58	0.58	9.8	62	65	0.55	0.55	10.7	10.2	0.61	0.61	0.86	0.85	1.00	1.00	1.13	1.08
859051525.A10	-0.89	0.077	0.97	1.05	-0.39	1.650	7.56	0.69	11.1	61	66	0.59	0.60	10.8	10.1	0.66	0.68	0.96	0.96	1.13	1.20	1.32	1.44
859051525.A11	-1.16	0.057	1.22	0.83	-0.31	1.343	6.24	0.66	11.1	62	64	0.52	0.54	10.7	10.3	0.57	0.60	0.80	0.85	0.99	1.03	1.14	1.13
859051525.A12	-1.32	0.044	1.36	0.96	-0.32	1.273	6.26	0.60	11.1	61	62	0.48	0.50	10.7	10.6	0.54	0.55	0.76	0.78	0.95	0.96	1.23	1.24
859051525.A13	-1.55	0.051	1.60	0.85	-0.34	1.223	6.33	0.56	11.1	62	61	0.44	0.46	10.7	10.8	0.49	0.50	0.67	0.71	0.85	0.87	1.16	1.19
859051525.A14	-1.88	0.062	1.94	0.74	-0.36	0.886	4.65	0.53	11.1	59	59	0.45	0.45	11.3	11.1	0.48	0.48	0.65	0.64	0.85	0.83	0.99	1.03
859060915.A03	-0.49	0.033	0.52	0.19	-0.17	-0.198	2.67	0.23	12.8	43	50	0.23	0.24	14.8	13.1	0.23	0.24	0.28	0.28	0.31	0.31	0.34	0.35
859060915.A04	-0.47	0.051	0.52	0.32	-0.13	1.132	5.03	0.21	11.1	49	55	0.24	0.24	13.5	12.2	0.24	0.24	0.28	0.30	0.32	0.33	0.34	0.40
859060915.A05	-0.45	0.035	0.49	0.40	-0.18	0.522	3.18	0.33	12.8	52	59	0.32	0.30	12.6	11.0	0.33	0.31	0.41	0.39	0.50	0.45	0.55	0.47
859060915.A07	-0.55	0.071	0.62	0.57	-0.24	0.952	4.49	0.43	12.8	63	62	0.42	0.42	10.5	10.7	0.44	0.44	0.57	0.56	0.66	0.67	0.76	0.76
859060915.A08	-0.66	0.040	0.70	0.88	-0.28	1.334	6.51	0.52	12.8	62	62	0.52	0.53	10.7	10.7	0.55	0.57	0.73	0.75	0.84	0.89	0.91	1.13
859060915.A09	-0.80	0.045	0.85	1.02	-0.28	1.935	9.45	0.57	9.8	69	69	0.52	0.53	9.6	9.6	0.58	0.60	0.83	0.86	1.02	1.04	1.22	1.26
859060915.A10	-0.98	0.032	1.01	1.10	-0.32	1.953	10.27	0.57	9.8	66	68	0.47	0.49	10.0	9.7	0.55	0.58	0.80	0.86	1.09	1.14	1.37	1.42
859060915.A11	-1.18	0.002	1.18	0.92	-0.28	1.625	8.06	0.54	12.8	61	62	0.44	0.47	10.7	10.7	0.49	0.53	0.70	0.76	0.92	0.98	1.05	1.16
859060915.A12	-1.40	-0.005	1.40	1.05	-0.27	1.390	7.74	0.51	12.8	64	62	0.42	0.43	10.4	10.7	0.48	0.50	0.69	0.74	0.98	1.00	1.26	1.32
859061015.A03	-0.49	0.282	0.77	0.42	-0.22	0.363	3.89	0.32	13.1	59	64	0.31	0.32	11.6	10.7	0.32	0.33	0.40	0.43	0.45	0.50	0.47	0.59
859061015.A04	-0.47	0.255	0.73	0.39	-0.17	1.083	4.80	0.33	10.1	66	70	0.33	0.33	10.2	9.7	0.34	0.35	0.43	0.44	0.48	0.50	0.51	0.54
859061015.A05	-0.45	0.231	0.68	0.53	-0.25	0.675	3.31	0.45	13.1	56	59	0.44	0.43	12.2	11.6	0.45	0.44	0.55	0.53	0.64	0.62	0.75	0.69
859061015.A06	-0.52	0.238	0.76	0.88	-0.29	0.600	4.33	0.47	13.1	64	63	0.44	0.43	10.7	10.8	0.46	0.46	0.60	0.59	0.75	0.75	1.06	1.13
859061015.A07	-0.55	0.218	0.77	0.71	-0.27	1.515	7.02	0.51	10.1	68	66	0.49	0.51	10.0	10.3	0.54	0.55	0.73	0.73	0.84	0.84	0.86	0.87
859061015.A08	-0.66	0.245	0.91	0.99	-0.27	1.641	8.26	0.58	13.1	74	76	0.52	0.50	9.3	8.9	0.58	0.57	0.83	0.83	1.00	0.99	1.20	1.22
859061015.A09	-0.80	0.228	1.03	1.11	-0.29	1.558	8.20	0.57	13.1	68	68	0.49	0.51	9.9	9.9	0.56	0.58	0.80	0.83	1.08	1.07	1.35	1.35
859061015.A10	-0.98	0.212	1.19	0.95	-0.30	1.379	7.95	0.53	10.1	65	70	0.43	0.43	10.4	9.7	0.48	0.49	0.68	0.68	0.91	0.92	1.20	1.24
859061015.A11	-1.18	-0.029	1.15	0.77	-0.28	1.110	5.62	0.52	13.1	67	67	0.42	0.42	10.2	10.2	0.45	0.46	0.61	0.62	0.80	0.81	0.97	0.99
859061015.A12	-1.40	0.211	1.61	0.63	-0.27	0.849	4.40	0.49	13.1	64	65	0.39	0.39	10.6	10.4	0.42	0.42	0.58	0.58	0.70	0.71	0.85	0.78
859061015.A13	-1.63	0.236	1.87	0.61	-0.25	0.811	4.16	0.44	13.1	63	65	0.35	0.35	10.7	10.5	0.38	0.38	0.50	0.51	0.59	0.61	0.80	0.81
859061015.A14	-1.91	0.234	2.14	0.46	-0.28	0.686	3.77	0.42	9.0	67	67	0.34	0.35	10.1	10.1	0.36	0.37	0.47	0.49	0.56	0.62	0.61	0.69

(Continued) (Sheet 2 of 3)

Table 4 (Concluded)

RUN ID	BED ELEV m	ELEV mean m	TOTAL DEPTH m	ELEV max m	ELEV min m	ELEV skewness	ELEV kurtosis	Hmo m	Tp sec	WAVES UP	WAVES DOWN	Havg UP m	Havg DOWN m	Tavg UP sec	Tavg DOWN sec	Hrms UP m	Hrms DOWN m	H1/3 UP m	H1/3 DOWN m	H1/10 UP m	H1/10 DOWN m	Hmax UP m	Hmax DOWN m
859061300.A03	-0.49	0.502	0.99	0.53	-0.21	1.742	7.46	0.40	9.0	61	67	0.41	0.45	11.2	10.1	0.44	0.47	0.56	0.57	0.60	0.61	0.65	0.65
859061300.A04	-0.47	0.508	0.98	0.60	-0.24	1.202	4.82	0.50	10.1	74	74	0.48	0.48	9.3	9.2	0.50	0.51	0.63	0.64	0.70	0.73	0.77	0.79
859061300.A05	-0.45	0.510	0.96	0.94	-0.30	1.298	6.55	0.54	11.4	68	69	0.54	0.56	10.1	9.9	0.58	0.59	0.78	0.76	0.96	0.93	1.17	1.15
859061300.A06	-0.52	0.524	1.04	0.80	-0.46	1.303	6.15	0.55	9.0	66	71	0.57	0.54	10.3	9.7	0.60	0.59	0.78	0.79	0.90	0.91	0.96	1.03
859061300.A07	-0.55	0.497	1.05	1.15	-0.34	1.721	9.45	0.59	10.1	68	66	0.54	0.56	10.0	10.3	0.61	0.62	0.88	0.88	1.13	1.13	1.46	1.48
859061300.A08	-0.66	0.526	1.19	0.83	-0.34	1.220	6.73	0.57	11.4	76	74	0.47	0.49	8.9	9.2	0.51	0.54	0.71	0.77	0.95	1.01	1.10	1.15
859061300.A09	-0.80	0.502	1.30	0.83	-0.28	1.247	6.36	0.52	9.0	71	72	0.44	0.44	9.6	9.4	0.48	0.49	0.66	0.67	0.84	0.87	1.00	1.03
859061300.A10	-0.98	0.504	1.48	0.69	-0.28	0.906	4.38	0.54	10.1	65	65	0.46	0.46	10.5	10.4	0.49	0.49	0.64	0.66	0.79	0.80	0.91	0.92
859061300.A11	-1.18	0.519	1.70	0.64	-0.29	0.659	3.70	0.51	11.4	68	67	0.41	0.42	10.0	10.1	0.44	0.45	0.58	0.59	0.75	0.76	0.86	0.89
859061300.A12	-1.40	0.489	0.89	0.53	-0.28	0.655	3.78	0.47	9.0	75	73	0.36	0.36	9.1	9.3	0.39	0.40	0.53	0.54	0.66	0.67	0.70	0.77
859061300.A13	-1.63	0.519	2.15	0.52	-0.27	0.761	4.10	0.44	9.0	69	70	0.35	0.35	9.9	9.7	0.37	0.38	0.50	0.51	0.63	0.61	0.76	0.69
859061300.A14	-1.91	0.518	2.43	0.61	-0.30	0.630	3.51	0.49	10.1	67	67	0.40	0.39	10.2	10.2	0.42	0.42	0.54	0.56	0.67	0.69	0.83	0.80
859061400.A03	-0.49	0.431	0.92	0.44	-0.26	0.795	5.63	0.33	13.0	57	63	0.34	0.37	11.7	10.6	0.36	0.39	0.46	0.48	0.52	0.55	0.56	0.59
859061400.A04	-0.47	0.473	0.94	0.47	-0.18	1.524	5.93	0.41	11.2	60	64	0.41	0.40	11.1	10.5	0.44	0.43	0.55	0.54	0.60	0.60	0.62	0.62
859061400.A05	-0.45	0.471	0.92	0.62	-0.24	0.968	4.38	0.53	12.8	59	58	0.52	0.52	11.3	11.5	0.55	0.55	0.69	0.68	0.75	0.76	0.81	0.82
859061400.A06	-0.52	0.479	1.00	0.71	-0.31	1.202	6.54	0.51	12.6	60	61	0.51	0.51	10.9	10.6	0.55	0.55	0.74	0.74	0.85	0.84	0.96	0.99
859061400.A07	-0.55	0.451	1.00	0.89	-0.24	2.012	10.23	0.53	10.9	67	61	0.50	0.53	9.9	10.8	0.57	0.59	0.84	0.84	1.01	1.01	1.07	1.09
859061400.A08	-0.66	0.448	1.11	0.96	-0.30	1.804	8.92	0.58	12.6	65	63	0.50	0.51	10.1	10.4	0.57	0.58	0.86	0.85	1.08	1.08	1.16	1.20
859061400.A09	-0.80	0.443	1.24	0.82	-0.29	1.289	7.20	0.54	12.8	61	61	0.44	0.45	10.8	10.7	0.50	0.50	0.70	0.72	0.96	0.93	1.07	1.07
859061400.A10	-0.98	0.467	1.45	0.63	-0.28	1.026	5.57	0.47	9.8	60	63	0.38	0.38	11.0	10.5	0.42	0.42	0.59	0.59	0.78	0.78	0.86	0.83
859061400.A11	-1.18	0.443	1.62	0.60	-0.24	0.931	4.57	0.46	11.1	62	65	0.35	0.36	10.7	10.1	0.39	0.40	0.54	0.55	0.67	0.72	0.83	0.80
859061400.A12	-1.40	0.416	1.82	0.56	-0.29	0.791	4.04	0.48	12.7	61	63	0.37	0.36	10.8	10.4	0.40	0.40	0.56	0.54	0.66	0.68	0.78	0.82
859061400.A13	-1.63	0.418	2.05	0.54	-0.29	0.772	3.93	0.47	12.7	61	61	0.36	0.36	10.8	10.8	0.39	0.39	0.54	0.54	0.65	0.64	0.75	0.76
859061400.A14	-1.91	0.433	2.34	0.44	-0.24	0.822	3.89	0.44	11.1	61	62	0.34	0.34	10.8	10.7	0.36	0.37	0.49	0.50	0.59	0.59	0.68	0.66

(Sheet 3 of 3)

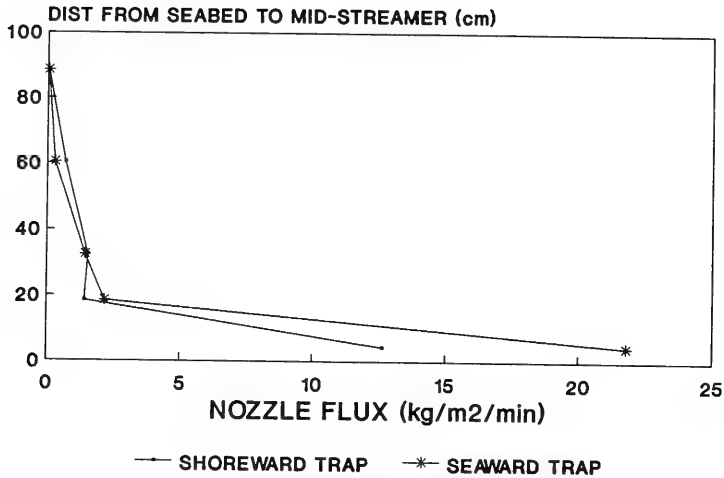
Sand Transport

Consistency runs

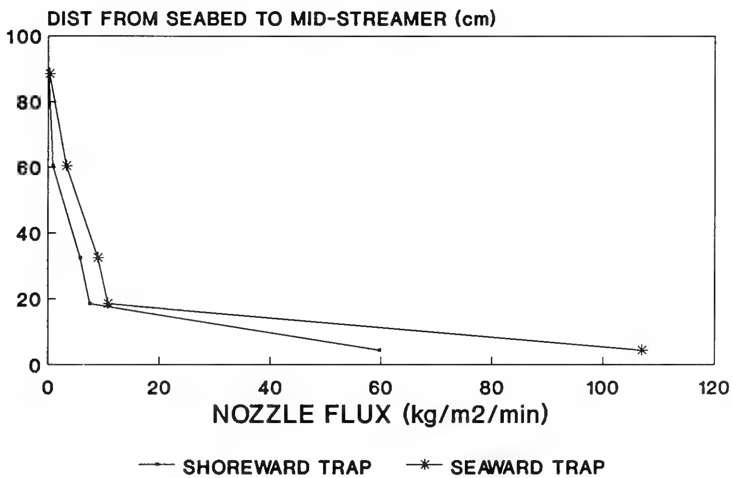
43. The results of nine representative consistency runs are included in this report (Tables 2 and A1). On the 4 September run, two pairs of traps were used; traps 1 and 2 were located nearest to shore and traps 3 and 4 were located about 12 m farther offshore (Table A2). Measured fluxes for the two traps are plotted on Figures 11a and 11b. The flux decreases approximately exponentially with elevation from the bed. A sharp decrease in flux was found in all deployments of the traps.

44. The magnitudes of the flux for each pair of traps are approximately equal at any elevation, but corresponding fluxes at the offshore traps were 4 to 8 times greater (note different x-axis scaling in Figures 11a and b). The relative magnitudes for any two trap pairs remain in proportion through the lowest three streamers; the highest (fifth) streamers show a sharp decrease in flux. These streamers were probably above water for a large part of the sampling interval. Although the magnitudes of the fluxes at each pair are consistent, taken to be evidence that the streamer trap is reliable, there is still a substantial difference between amounts at any one elevation for the individual traps. Differences at the lowest streamer might arise from differences in scour patterns or from slight differences in elevation of the bottom streamer. However, measured fluxes at the higher elevations should not be affected by scour or by slight differences in streamer height and must therefore reflect the actual transport process. It is concluded that, within a distance of 1 to 2 m across shore, the longshore sand transport rate can differ by at least a factor of 2 under wave and current conditions as encountered in these experiments. Traps placed close together sometimes gave fluxes that were almost identical through the water column, as shown in Figure 12 for Run 85909AM6.

45. In examination of the trapped sand amounts listed in Table A1 for the consistency runs, it is seen that the trap with the greatest amount in the lowest streamer has correspondingly greater amounts in the upper streamers, with the exception of one run (85909AM4). The relatively small amount of sand collected by streamer 1 of trap 1 in Run 85909AM4 is believed to be a result



(a) Traps 1 and 2



(b) Traps 3 and 4

Figure 11. Fluxes measured in consistency Run 859041515

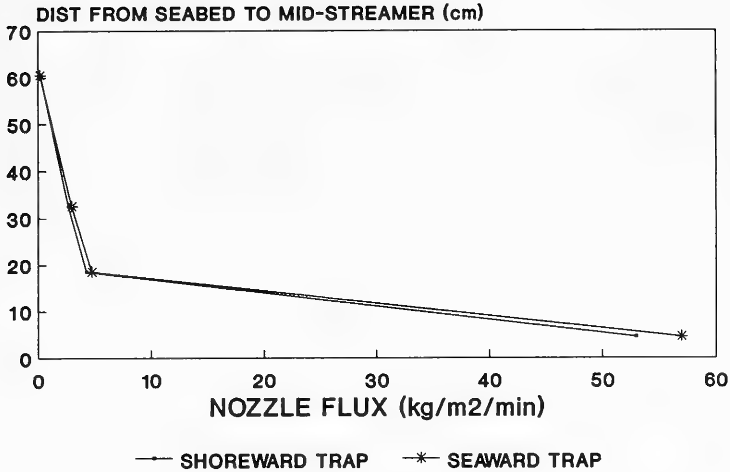


Figure 12. Fluxes measured in consistency Run 85909AM6

of the streamer not residing on the bottom throughout the sampling period. However, it can not be ruled out that a local bedform altered the transport rate at the bottom. The proportionate amounts of sand trapped in pairs of traps in the great majority of consistency runs indicate that the traps will give reliable results if operated carefully.

Cross-shore distributions

46. In this section transport rate data from eight cross-shore distribution runs are presented in graphical form as a summary of results (Figures 13a-h). The plotted fluxes were determined by dividing the directly collected weights listed in Table A1 by the sand transport efficiencies (Rosati and Kraus in preparation) of 0.13 for the bottom streamer and 0.92 for streamers higher in the water column. In the cross-shore distribution runs, 6 or 7 traps were deployed simultaneously across the surf zone with separation distances of either one half or one full interval between photopoles (approximately 3 m and 6 m, respectively). The width of the surf zone (mean water shoreline to average break point) was in the approximate range of 15 to 40 m.

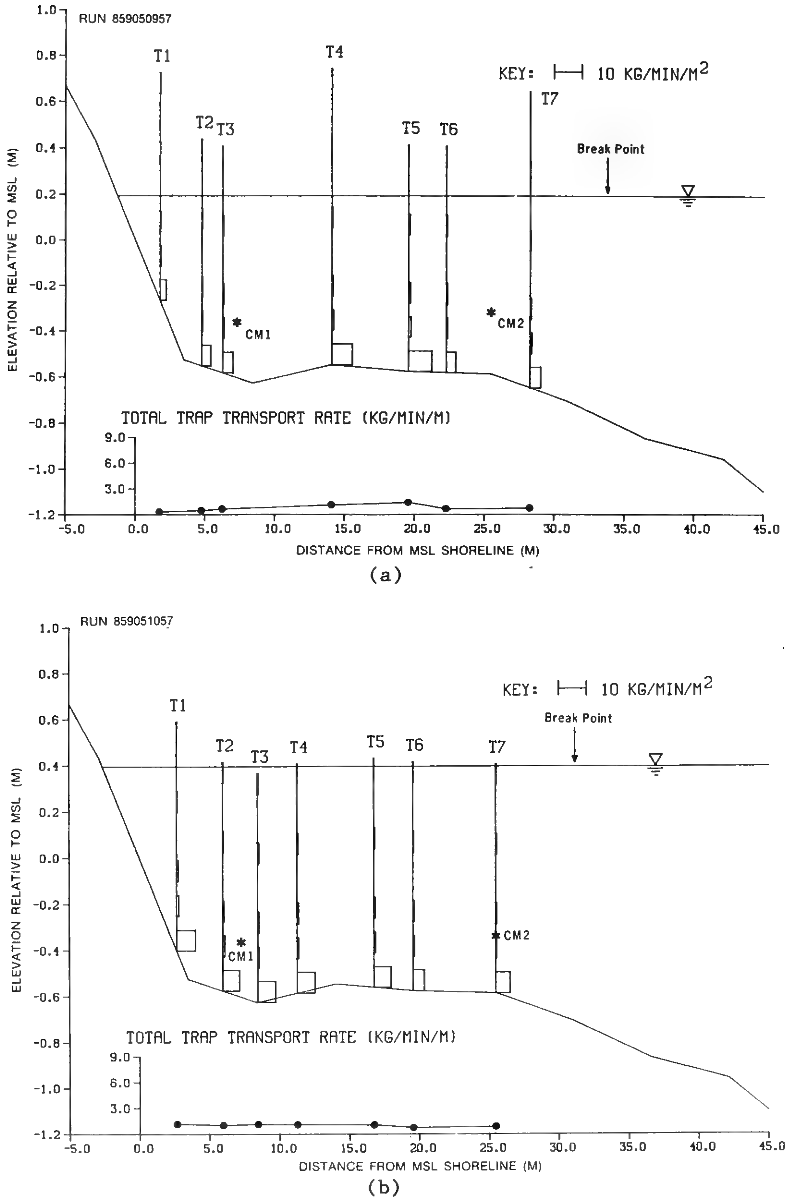
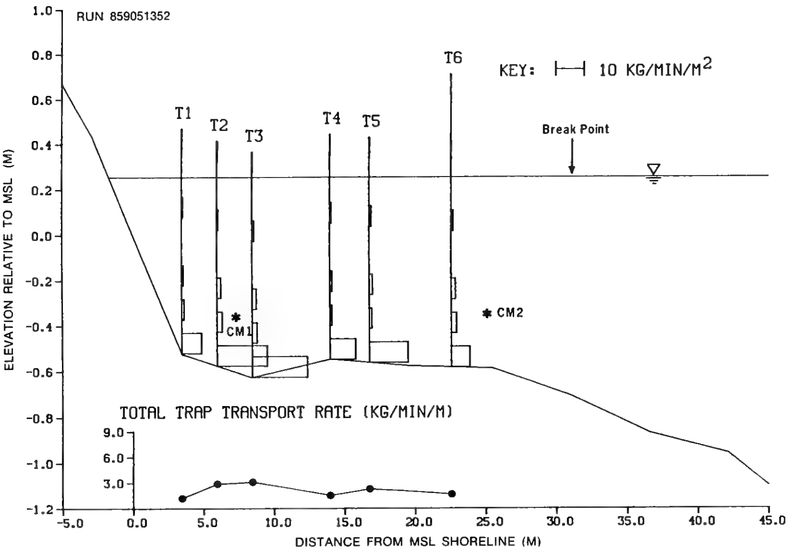
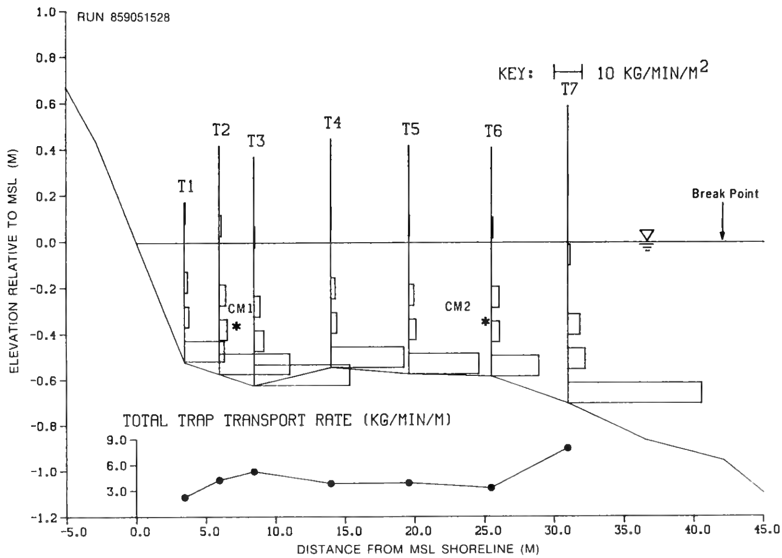


Figure 13. Cross-shore distributions of the longshore sand transport rate (Sheet 1 of 4)

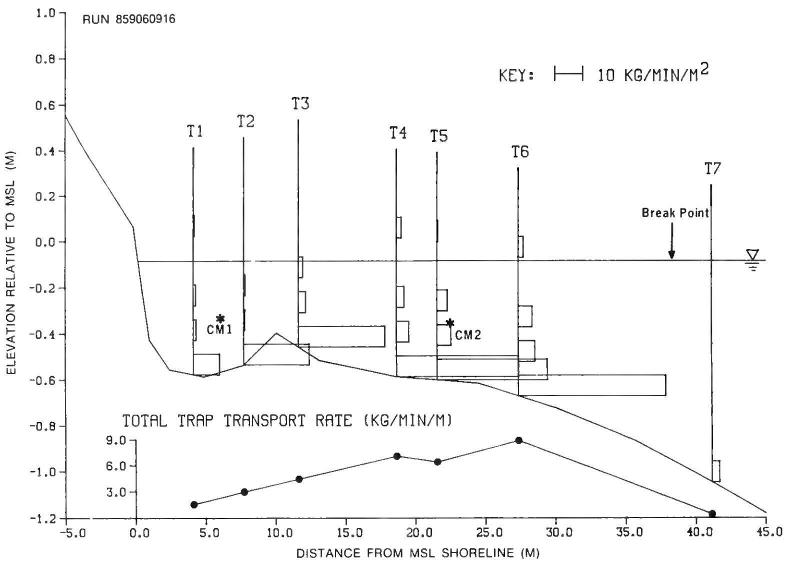


(c)

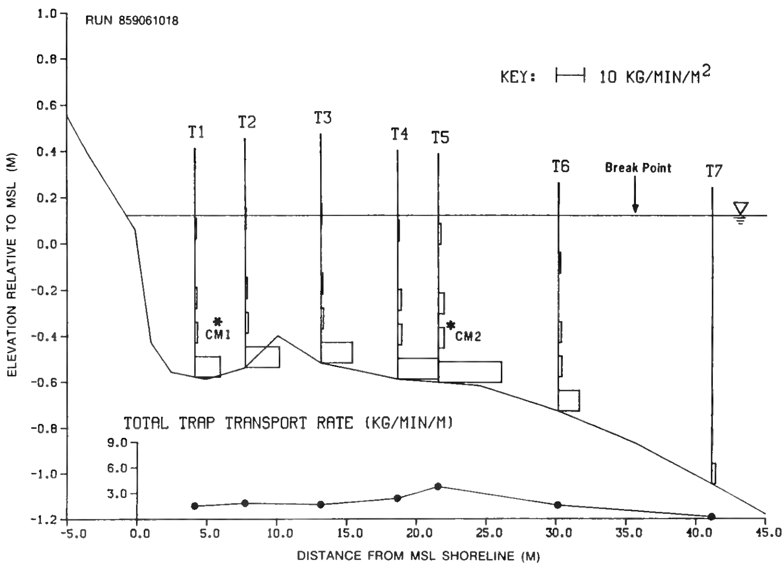


(d)

Figure 13. (Sheet 2 of 4)

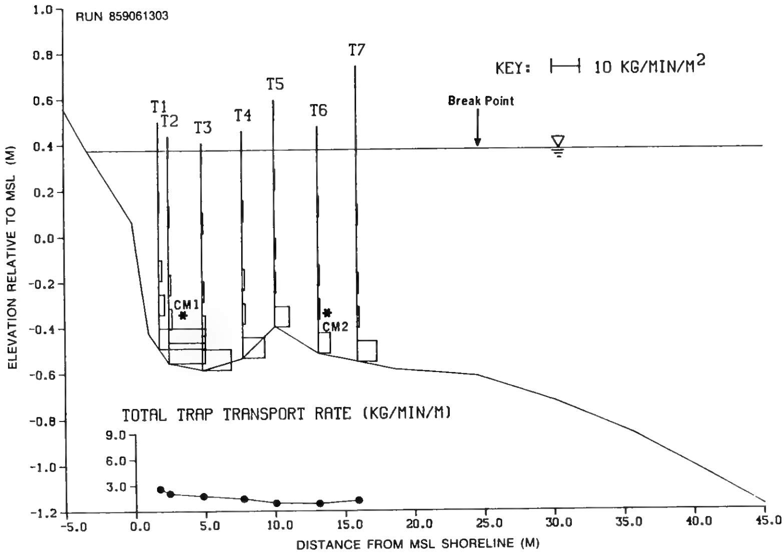


(e)

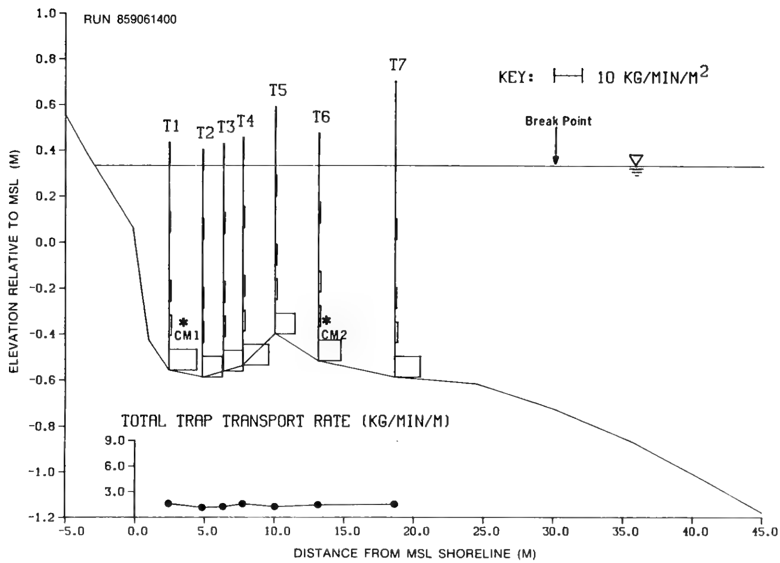


(f)

Figure 13. (Sheet 3 of 4)



(g)



(h)

Figure 13. (Sheet 4 of 4)

Figure 13 shows the mean water level during the run, position of the traps, bottom profile, vertical distribution of the flux, and cross-shore distributions as determined from Equation 3. Figure 13 replaces similar figures presented by Kraus and Dean (1987) by incorporating trap efficiencies and correcting for a calculation error.

47. Considerable information is contained in Figure 13, some of which has been discussed by Kraus and Dean (1987) and Kraus, Gingerich, and Rosati (1988). It is clear that transport on and near (within 9 cm of) the bed predominated in these experiments. The magnitude of the longshore flux, represented by the length of the histograms, decreased sharply above the bottom streamer. At some traps, a nonzero flux is observed above the mean water level; this material was collected as it moved alongshore during periods of higher water elevation and in wave crests as they passed by the traps. It is also noted that the shape of the vertical distribution is essentially independent of position in the surf zone, i.e., irrespective of whether a trap was located in the inner, middle, or outer surf zone; or at the inner bar or trough. An irregular vertical distribution is rarely seen (i.e., a distribution with a shape other than monotonically decreasing). At the two runs with a trap located seaward of the mean breaker line (positioned just seaward of the region of visibly significant breaking waves), a relatively small amount of sand was collected, clear evidence that the longshore sand transport rate drops off sharply seaward of the breaking wave zone. The operator of the trap located seaward of the breaker line noted a significant longshore current at that position, and the streamers remained extended. Evidently, the absence of turbulence and associated sediment entrainment produced by breaking waves resulted in a low transport rate compared to the surf zone rates.

48. Cross-shore distributions are shown in the lower portion of Figures 13a-h. On the basis of multicolor sand tracer field experiments, Kraus et al. (1982) found that even on near-planar profile shapes, the cross-shore distribution can take at least four different forms: a single peak in the outer surf zone, just shoreward of the wave breakers; a single peak in the inner surf zone; peaks in the inner and outer surf zone; and a uniform flat shape (very broad peak) across the surf zone. In the present experiments, discounting small peaks as being within the range of measurement variability,

a uniform distribution was most common. Run 859060916 showed a clear peak in the outer surf zone, and Run 859051528 showed a bimodal distribution with a large peak in the outer surf zone and a small peak in the inner surf zone. It is again noted that during DUCK85 the steep foreshore step was covered with pebbles, and longshore transport was not observed there. Because of the armoring and potential artificial suppression of transport on the foreshore, the determined distributions cannot be considered as reflecting transport behavior that might occur on a beach with a sandy foreshore.

Total transport

49. The eight cross-shore transport distributions shown in Figure 13 were integrated from the mean water shoreline to the most seaward trap or to the break point (where the transport rate was assumed to be zero) to give the total longshore sand transport rate. The measured total transport rates were converted to an immersed weight transport rate, denoted by the symbol I, and expressed in terms of a quantity called the "discharge parameter" (Kraus and Dean 1987; Kraus, Gingerich, and Rosati 1988) defined as:

$$R = V X_b H_b \tag{4}$$

in which

R = discharge parameter (m^3/sec)

V = average longshore current speed (m/sec)

X_b = average width of the surf zone (m)

H_b = average significant breaking wave height (m)

Values of these quantities are listed in Table 5.

50. The total longshore transport rate is plotted as a function of the discharge parameter in Figure 14. An approximate linear relation is found, resulting in a least squares fit equation of $I = 2.7 (R - R_c)$ (correlation coefficient $r^2 = 0.76$), in which the intercept $R_c = 3.9\ m^3$/sec is interpreted as a threshold value for significant longshore transport to take place, and I is expressed in the units of N/sec. Reasonable visual agreement is seen.

Table 5

Total Transport Rates and Associated Variables

Run ID No.	V m/sec	X_b m	H_b m	R m^3/sec	I^* kg/sec	I^{**} N/sec
859050957	0.11	35.1	1.06	4.02	0.45	2.71
859051057	0.17	33.7	0.97	5.65	0.49	2.95
859051352	0.17	32.8	1.19	6.51	0.91	5.47
859051528	0.22	42.1	0.96	8.96	2.96	17.81
859060916	0.30	38.2	0.86	10.00	3.23	19.43
859061018	0.29	36.5	0.83	8.84	1.15	6.92
859061303	0.22	27.9	0.88	5.43	0.54	3.25
859061400	0.18	33.1	0.85	4.95	0.63	3.79

* Dry Mass Transport Rate
** Immersed Weight Transport Rate

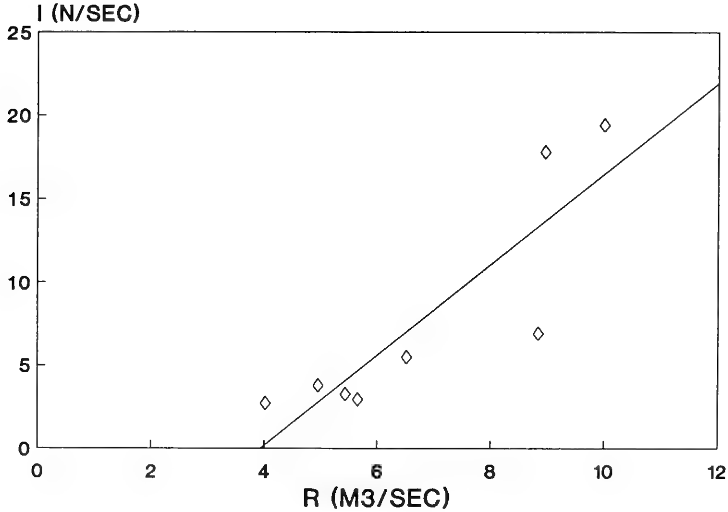


Figure 14. Total transport rate

PART IV: CONCLUDING DISCUSSION

51. Previous field data collection efforts aimed at making point measurements of longshore sand transport in the surf zone have either measured the suspended sand concentration, from which a rate must be inferred by taking the product with a longshore current speed, or have used traps to measure only bedload transport. Neither of these two methods taken individually provides the total transport rate. To the authors' knowledge, the DUCK85 surf zone experiments described here were the first to directly and synoptically measure the longshore sand flux through the water column and across the surf zone in the field or the laboratory. Although the DUCK85 field data collection project was originally aimed to be a test of equipment and procedures, a considerable amount of high-quality data was obtained under the ideal wave, current, and sediment transport conditions encountered.

52. The portable streamer traps developed in this project were found to give reliable and consistent results by comparison of fluxes obtained with traps placed close to each other. Measured cross-shore distributions did not show anomalous or peculiar shapes, but agreed with previous results in a qualitative way. Uniform (flat) cross-shore distributions predominated in these experiments, although peaked shapes were occasionally found. The transport rate was effectively zero immediately outside the wave breaker zone. Vertical distributions of the sand flux decreased sharply with elevation from the bed and had an approximate exponential shape independent of position in the surf zone. Total surf zone transport rates correlated reasonably well with a simple parameter related to the average longshore discharge of water.

53. Although portable traps appear to be a primitive means to measure the sand transport rate, they have numerous advantages, including low construction and maintenance costs, capability to directly measure the sand flux both at the bed and in the water column, ease of movement in the surf zone to obtain point measurements where desired, and an averaging or measurement interval compatible with engineering theories and models of sand transport and beach change. The limitations of traps must also be kept in mind. In general, they work best in conditions where the flow does not reverse, and

where an operator can attend them to correct for streamer fouling and lifting of the trap off the bottom.

54. The described data collection project was performed with minimal investment in equipment, yet a valuable data set was collected that may well be unique in completeness and detail. It is believed that numerous improvements can be made in trap technology for use in the coastal zone, and it is recommended that researchers reevaluate traps as an alternative measurement method to tracer and impoundment techniques and for augmenting efforts being made to develop and deploy sophisticated remote sensing instrumentation.

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APPENDIX A: DATA

1. This appendix contains a listing of the basic data collected during the DUCK85 surf zone sand transport experiments. Data are given for the following quantities:

<u>a</u>. Wet weight of collected sand (Table A1).

<u>b</u>. Trap locations in the Field Research Facility (FRF) coordinate system (Table A2).

<u>c</u>. Current meter locations in the FRF coordinate system (Table A3).

<u>d</u>. Water levels during the experiments (Table A4).

<u>e</u>. Beach profiles in the vicinity of the experiment (Table A5).

<u>f</u>. Calculated transport rate densities for eight cross-shore runs (Table A6).

<u>g</u>. Grain size data (Table A7).

2. Table A1 gives the weight of the sand collected in the streamers as recorded in the field logbooks, without adjustments for trap efficiency. A value of '0.0' indicates that no sand was collected in the streamer and '---' denotes no streamer at that elevation. The wet sand was weighed in a drip-free state in small patches of sieve cloth, and the weight of the sieve cloth was subtracted to arrive at the values given in Table A1. The drip-free wet weight (WW) and the dry weight (DW) of samples consisting primarily of sand are linearly related (Kraus and Nakashima 1986)* for a wide range of common grain sizes and sample weights as:

$$DW = c\ WW \tag{A1}$$

for which the empirical coefficient c must be determined through calibration for the particular field operation and weighing procedure, since judgement of the drip-free state is somewhat subjective. The value c = 0.76 was obtained

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* References cited in the Appendix can be found in the list of references at the end of the main text.

for the DUCK85 experiments. The elevations listed in Table A1 give the height of the center of the streamer nozzle from the bed.

3. Table A2 gives the locations of the traps in the FRF coordinate system (Figure 2, main text). The x-coordinate is pointed alongshore (increases to the north) and the y-coordinate points offshore.

4. Table A3 lists positions of current meters 1 and 2 in FRF coordinates for each day of experiment runs.

5. Table A4 lists water levels recorded at a tide gage located at the end of the FRF pier during the times of the experiment runs.

6. Table A5 gives the profile surveyed at the photopole line on major run days. The z-coordinate gives distance measured from the National Geodetic Vertical Datum (NGVD), which is related to Mean Sea Level (MSL) at the FRF by the relation MSL(m) = NGVD(m) + 0.067. The information in this table can be combined with the water levels given in Table A4 to find the total depth at any position along the profile during an experiment run.

7. Table A6 gives trap locations relative to the mean water shoreline, water depth at the traps, and transport rate densities calculated by Equation 3 for the eight cross-shore distribution runs plotted in Figure 13. The transport rate densities are expressed in terms of dry mass (kg) and immersed weight (N).

8. Table A7 summarizes grain size statistics (calculated using Moment and Folk methods (Friedman and Johnson 1982)) for samples retained from 20 traps representing 3 experiment runs.

Table A1

Wet Weight of Sediment, g

Streamer Number	Elev. m	Trap No. 1	2	3	4	5	6	7
		859041515 - Consistency Run						
1	0.045	102.4	176.6	483.9	866.7			
2	0.195	87.1	132.7	456.9	656.5			
3	0.345	93.4	88.2	354.3	545.7			
4	0.645	41.5	18.4	52.6	199.0			
5	0.945	2.3	2.7	5.8	15.1			
		859050957 - Cross-shore Run						
1	0.045	23.2	35.0	41.1	80.9	91.3	37.5	42.2
2	0.195	16.6	18.7	39.6	44.4	67.4	36.0	54.0
3	0.345	6.1	11.8	24.7	34.8	52.7	32.5	31.8
4	0.645	2.3	4.3	17.5	14.4	41.5	25.4	17.7
5	0.945	0.8	0.2	4.1	0.8	3.9	6.1	7.0
6	1.245	---	---	---	1.2	---	---	0.0
		859051057 - Cross-shore Run						
1	0.045	146.4	129.4	139.0	138.0	132.8	87.2	110.4
2	0.195	126.1	124.4	82.2	85.7	95.8	80.0	47.0
3	0.345	101.4	68.8	82.3	87.1	81.0	58.2	53.5
4	0.645	39.4	44.3	66.5	65.1	61.1	48.6	55.4
5	0.945	12.2	19.0	46.5	13.2	10.6	15.8	29.3
		859051352 - Cross-shore Run						
1	0.045	152.2	386.8	424.7	199.1	300.2	142.8	
2	0.195	126.5	293.1	271.6	113.7	146.3	304.0	
3	0.345	91.0	223.0	233.1	121.5	186.6	243.5	
4	0.645	54.3	74.6	103.2	81.9	125.3	124.7	
5	0.945	17.0	42.1	14.3	14.9	23.8	8.0	
6	1.245	---	---	---	---	---	4.0	
		859051528 - Cross-shore Run						
1	0.045	312.1	550.5	747.7	571.5	546.5	371.4	1043.5
2	0.195	249.3	467.9	564.4	332.4	416.4	464.2	991.8
3	0.345	174.3	374.4	355.1	245.9	290.2	446.1	694.5
4	0.645	55.6	132.7	53.4	19.7	47.5	100.6	140.2
5	0.945	---	5.6	1.2	0.1	2.1	4.1	12.5
6	1.245	---	---	---	---	---	---	2.1

(Continued) (Sheet 1 of 5)

Table A1 (Continued)

Streamer Number	Elev. m	Trap No. 1	2	3	4	5	6	7
		859060916 - Cross-shore Run						
1	0.045	203.2	509.0	674.7	951.7	859.0	1147.5	58.4
2	0.195	163.0	71.2	411.8	713.5	795.5	960.0	17.5
3	0.345	130.8	81.2	247.5	447.8	599.5	801.4	6.6
4	0.645	47.5	3.3	6.5	286.5	42.3	290.8	8.4
5	0.945	3.6	0.0	0.0	6.7	8.8	10.5	10.5
6	1.245	---	---	---	---	---	---	18.5
		859061018 - Cross-shore Run						
1	0.045	196.7	265.8	245.2	318.8	492.3	164.9	31.2
2	0.195	147.7	165.5	139.2	231.9	335.7	199.4	14.8
3	0.345	112.8	110.7	99.4	192.5	324.2	171.0	9.3
4	0.645	74.1	45.1	40.7	85.3	144.6	116.8	5.5
5	0.945	15.6	2.8	1.0	3.5	12.4	24.7	3.2
6	1.245	---	---	---	---	---	---	0.0
		859061303 - Cross-shore Run						
1	0.045	362.0	284.0	225.1	170.8	114.3	94.0	151.6
2	0.195	326.2	188.5	193.8	154.9	74.5	101.5	120.8
3	0.345	183.6	122.1	112.1	130.3	75.9	80.1	82.1
4	0.645	32.2	66.3	79.9	77.4	48.4	55.5	56.9
5	0.945	0.0	16.6	16.8	10.1	6.9	12.1	8.8
6	1.245	---	---	---	---	---	---	1.3
		859061400 - Cross-shore Run						
1	0.045	217.1	155.6	155.3	201.3	154.9	176.7	198.3
2	0.195	130.0	69.6	111.9	126.9	123.8	121.6	154.7
3	0.345	100.8	69.9	87.6	113.7	100.7	130.5	87.1
4	0.645	51.4	50.6	81.3	88.2	62.7	93.9	83.3
5	0.945	35.9	30.2	13.2	30.8	17.3	28.8	12.8
6	1.245	---	---	---	---	---	---	0.0
		859070922 - Consistency Run						
1	0.045	1114.5	2212.5					
2	0.195	1214.0	1818.8					
3	0.345	831.1	1553.4					
4	0.645	212.0	472.3					
5	0.945	10.8	6.3					

(Continued) (Sheet 2 of 5)

Table A1 (Continued)

Streamer Number	Elev. m	Trap No. 1	2	3	4	5	6	7
		859071000 - Cross-shore Run						
1	0.045	17.5	198.5	398.9	471.1	111.5	1357.8	
2	0.195	11.8	69.0	266.7	331.9	1092.5	995.4	
3	0.345	17.6	48.2	170.0	217.6	661.0	1004.1	
4	0.645	5.0	7.8	6.8	27.6	171.7	361.5	
5	0.945	0.0	3.1	2.9	1.5	3.5	9.2	
6	1.245	---	---	---	---	---	0.8	
		859071110 - Cross-shore Run						
1	0.045	195.6	221.4	312.9	719.1	252.8	97.6	
2	0.195	133.4	128.9	195.7	628.5	281.4	79.3	
3	0.345	86.1	86.9	191.5	424.7	66.8	60.1	
4	0.645	51.3	44.9	102.2	175.5	158.1	61.0	
5	0.945	12.0	5.7	2.2	13.0	65.7	23.8	
6	1.245	---	---	---	---	---	18.0	
		859071324 - Consistency Run						
1	0.045	187.4	95.1					
2	0.195	71.9	51.5					
3	0.345	59.8	49.4					
4	0.645	46.4	46.3					
5	0.945	10.2	12.1					
		859090804 - Rip Current Run						
1	0.045	828.5	2397.4	1677.3	2029.5	1099.1	594.7	850.5
2	0.195	1295.4	1241.0	1134.4	1358.5	946.7	267.1	674.4
3	0.345	1460.1	678.5	971.4	965.9	656.4	25.9	380.6
4	0.645	210.0	6.7	246.1	440.8	398.4	11.5	7.3
5	0.945	3.0	4.3	4.5	19.0	58.5	0.0	4.4
6	1.245	---	---	---	---	0.0		
		85909AM1 - Consistency Run						
1	0.045	946.5	1004.5					
		85909AM2 - Consistency Run						
1	0.045	1179.0	1133.4					

(Continued) (Sheet 3 of 5)

Table A1 (Continued)

Streamer Number	Elev. m	Trap No. 1	2	3	4	5	6	7
		85909AM3 - Consistency Run						
1	0.045	1277.9	1160.4					
		85909AM4 - Consistency Run						
1	0.045	417.9	476.3					
2	0.195	237.0	193.8					
3	0.345	161.1	78.4					
4	0.645	11.8	7.1					
		85909AM5 - Consistency Run						
1	0.045	829.1	1032.4					
2	0.195	479.5	536.9					
3	0.345	292.4	332.6					
4	0.645	8.5	20.1					
		85909AM6 - Consistency Run						
1	0.045	857.8	923.0					
2	0.195	520.5	579.0					
3	0.345	322.4	359.0					
4	0.645	24.3	21.4					
		85909AM7 - Consistency Run						
1	0.045	655.5	408.8					
2	0.195	469.1	267.7					
3	0.345	295.9	123.4					
4	0.645	84.1	70.8					
		859091400 - Consistency Run						
1	0.045	256.8	147.9					
2	0.195	208.0	128.9					
3	0.345	159.6	105.4					
4	0.645	116.7	78.3					
5	0.945	28.9	26.1					

(Continued) (Sheet 4 of 5)

Table A1 (Concluded)

Streamer Number	Elev. m	Trap No. 1	2	3	4	5	6	7
		859091417 - Consistency Run						
1	0.045	258.0	463.8					
2	0.195	206.2	357.4					
3	0.345	169.6	262.0					
4	0.645	95.2	159.6					
5	0.945	37.9	91.8					
		859091432 - Consistency Run						
1	0.045	1012.4						
2	0.195	915.8						
3	0.345	704.0						
4	0.645	690.8						
5	0.945	320.6						

(Sheet 5 of 5)

Table A2

Trap Locations Relative to FRF Coordinate System

X-Coordinate m		Y-Coordinate m
	859041515 Trap #	
957.8	1	132.5
958.8	2	133.5
957.1	3	144.0
958.1	4	145.0
	859050957 Trap #	
958.4	1	117.4
958.3	2	120.4
958.3	3	121.9
958.0	4	129.7
957.8	5	135.2
957.7	6	137.9
957.4	7	143.9
	859051057 Trap #	
958.4	1	118.3
958.3	2	121.6
958.3	3	124.1
958.1	4	129.6
957.9	5	132.4
957.8	6	135.2
957.7	7	141.1
	859051352 Trap #	
958.3	1	119.1
958.3	2	121.6
958.3	3	124.1
958.0	4	129.6
957.9	5	132.4
957.7	6	138.2

(Continued) (Sheet 1 of 4)

Table A2 (Continued)

X-Coordinate m		Y-Coordinate m
	859051528 Trap #	
958.3	1	119.1
958.3	2	121.6
958.3	3	124.1
958.0	4	129.6
957.8	5	135.2
957.7	6	141.1
957.2	7	146.6
	859060916 Trap #	
958.4	1	120.7
958.4	2	124.3
958.2	3	128.2
957.9	4	135.2
957.7	5	138.1
957.3	6	143.9
956.8	7	157.7
	859061018 Trap #	
958.4	1	120.7
958.4	2	124.3
958.0	3	129.7
957.9	4	135.2
957.7	5	138.1
957.2	6	146.7
956.8	7	157.7
	859061303 Trap #	
958.4	1	118.3
958.3	2	119.0
958.5	3	121.4
958.4	4	124.3
958.4	5	126.6
958.0	6	129.7
957.6	7	135.2

(Continued)

Table A2 (Continued)

X-Coordinate m		Y-Coordinate m
	859061400 Trap #	
958.3	1	119.0
958.5	2	121.4
958.4	3	122.9
958.4	4	124.3
958.4	5	126.6
958.0	6	129.7
957.9	7	135.2
	859070922 Trap #	
957.8	1	138.1
958.8	2	139.1
	859071000 Trap #	
958.2	1	119.1
958.2	2	124.1
957.8	3	129.7
957.7	4	135.3
957.3	5	141.2
957.5	6	144.3
	859071110 Trap #	
958.2	1	119.1
958.2	2	124.1
957.8	3	129.7
957.7	4	135.3
957.3	5	141.2
956.7	6	146.8
	859071324 Trap #	
957.8	1	138.1
958.8	2	139.1

(Continued)

Table A2 (Concluded)

X-Coordinate m		Y-Coordinate m
	859090804 Trap #	
---	1	119.0
---	2	129.7
---	3	128.0
---	4	149.4
---	5	152.2
---	6	124.2
---	7	128.0

(Sheet 4 of 4)

Table A3

Current Meter Locations

Date	Current Meter No.	X-Coordinate m	Y-Coordinate m
850904	1	955.6	140.4
	2	955.6	126.7
850905	1	955.6	122.1
	2	955.6	140.4
850906(AM)	1	955.1	122.6
	2	954.3	138.8
850906(PM)	1	955.5	119.6
	2	954.2	130.0
850907	1	954.3	121.3
	2	952.5	143.7

Table A4

Water Levels

Time (EDST)		Water Level m (NGVD)
	859041515	
1500		0.00
1506		-0.02
1512		-0.03
	859050957	
0954		0.23
1000		0.26
1006		0.28
	859051057	
1054		0.43
1100		0.47
1106		0.47
1112		0.47
	859051352	
1354		0.32
1400		0.31
1406		0.34
	859051528	
1524		0.09
1530		0.07
1536		0.06
1542		0.02
	859060916	
0912		-0.07
0918		-0.02
0924		-0.02
0930		0.02
	859061018	
1018		0.17
1024		0.18
1030		0.23
	859061303	
1300		0.44
1306		0.43
1312		0.43
1318		0.46
	859061400	
1400		0.41
1406		0.41
1412		0.39

(Continued)

Table A4 (Concluded)

Time (EDST)		Water Level m (NGVD)
	859070922	
0918		-0.09
0924		-0.05
0930		-0.05
0936		-0.03
	859071000	
1000		0.04
1006		0.06
1012		0.08
	859071110	
1106		0.26
1112		0.29
1118		0.31
1124		0.34
	859071324	
1324		0.53
1330		0.52
1336		0.51
	859090804	
0800		-0.25
0806		-0.26
0812		-0.23
0818		-0.27
	859091400	
1400		0.34
1406		0.37
1412		0.38
	859091417	
1412		0.38
1418		0.41
1424		0.43
1430		0.40
	859091432	
1430		0.40
1436		0.38
1442		0.46

Table A5

Profile Survey Data in FRF Coordinate System

X-Coordinate m	Y-Coordinate m	Z-Coordinate m (NGVD)
	859041300	
952.94	83.06	2.81
952.77	85.94	2.69
952.67	90.81	2.42
952.55	94.67	2.12
952.21	99.33	1.71
951.94	106.84	1.96
952.06	106.88	1.12
951.67	113.07	0.49
951.40	119.11	-0.41
951.31	124.27	-0.67
950.91	129.76	-0.53
950.75	135.26	-0.61
950.51	141.23	-0.70
950.18	141.76	-0.70
949.84	152.16	-0.83
949.95	157.65	-0.95
949.38	163.26	-1.16
949.24	168.98	-1.33
948.89	174.82	-1.44
	859051730	
952.92	81.50	3.05
952.49	90.70	2.41
952.52	94.62	2.13
952.34	100.37	1.64
952.04	106.77	1.16
951.69	112.76	0.50
951.30	119.13	-0.46
951.26	124.04	-0.56
950.98	129.64	-0.48
950.77	135.22	-0.51
950.66	141.10	-0.52
950.16	146.65	-0.64
949.88	152.20	-0.80
949.93	157.79	-0.89
949.41	163.20	-1.16
949.32	169.00	-1.32
948.81	174.76	-1.55
949.17	183.01	-1.88

(Continued) (Sheet 1 of 3)

Table A5 (Continued)

X-Coordinate m	Y-Coordinate m	Z-Coordinate m (NGVD)
	859061220	
953.30	82.70	2.80
952.66	90.77	2.43
952.62	94.86	2.11
952.22	100.36	1.64
952.11	104.18	1.38
951.98	106.91	1.16
951.93	110.21	0.77
951.77	113.13	0.45
951.53	116.41	0.13
951.43	117.56	-0.36
951.29	119.00	-0.49
951.50	121.44	-0.52
951.37	124.26	-0.47
951.39	126.63	-0.33
951.02	129.72	-0.45
950.85	135.18	-0.52
950.48	141.07	-0.55
950.20	146.69	-0.66
949.81	152.24	-0.80
949.84	157.70	-0.98
949.22	163.22	-1.17
949.19	169.05	-1.40
948.74	174.82	-1.63
949.15	183.02	-1.91
	859071030	
952.94	83.14	2.18
952.58	90.81	2.43
952.46	94.74	2.17
952.12	101.05	1.60
951.88	104.95	1.37
951.82	111.23	0.71
951.57	112.98	0.49
951.60	113.03	0.49
951.55	116.37	0.04
951.23	119.12	-0.46
951.66	121.83	-0.55
951.18	124.14	-0.29
951.09	127.06	-0.24
950.81	129.70	-0.29
950.68	132.82	-0.29

(Continued) (Sheet 2 of 3)

Table A5 (Concluded)

X-Coordinate m	Y-Coordinate m	Z-Coordinate m (NGVD)
950.68	135.25	-0.35
950.79	138.18	-0.33
950.33	141.24	-0.48
950.48	144.30	-0.51
949.71	146.82	-0.56
949.90	150.03	-0.66
949.34	152.29	-0.77
949.88	154.53	-0.84
949.30	157.72	-0.93
949.59	160.38	-1.02
948.78	161.14	-1.18
949.02	169.04	-1.39
948.68	174.88	-1.62
949.15	182.80	-1.85

(Sheet 3 of 3)

Table A6

Transport Rate Densities in Cross-Shore Distribution Runs

Trap No.	Distance Offshore m	Depth m	Total Transport kg/(m-min)	Total Transport N/(m-sec)
		859050957		
1	3.03	0.46	0.31	0.03
2	6.03	0.74	0.47	0.05
3	7.53	0.77	0.67	0.07
4	15.33	0.74	1.13	0.11
5	20.83	0.77	1.44	0.14
6	23.53	0.77	0.68	0.07
7	29.53	0.84	0.75	0.08
		859051057		
1	5.27	0.79	1.15	0.12
2	8.57	0.97	1.03	0.10
3	11.07	1.02	1.14	0.11
4	13.87	0.98	1.10	0.11
5	19.37	0.95	1.06	0.11
6	22.17	0.97	0.75	0.08
7	28.07	0.98	0.86	0.09
		859051352		
1	5.17	0.78	1.20	0.12
2	7.67	0.83	2.90	0.29
3	10.17	0.88	3.12	0.31
4	15.67	0.80	1.54	0.15
5	18.47	0.82	2.31	0.23
6	24.27	0.84	1.66	0.17
		859051528		
1	3.42	0.52	2.26	0.23
2	5.92	0.57	4.24	0.42
3	8.42	0.62	5.23	0.52
4	13.92	0.54	3.83	0.38
5	19.52	0.57	3.89	0.39
6	25.42	0.58	3.29	0.33
7	30.92	0.70	7.92	0.79

(Continued)

Table A6 (Concluded)

Trap No.	Distance Offshore m	Depth m	Total Transport kg/(m-min)	Total Transport N/(m-sec)
		859060916		
1	3.93	0.49	1.54	0.15
2	7.53	0.45	2.98	0.30
3	11.43	0.37	4.45	0.44
4	18.43	0.50	7.07	0.71
5	21.33	0.51	6.39	0.64
6	27.13	0.58	8.88	0.89
7	40.93	0.96	0.40	0.04
		859061018		
1	4.94	0.70	1.53	0.15
2	8.54	0.66	1.86	0.19
3	13.94	0.64	1.69	0.17
4	19.44	0.71	2.40	0.24
5	22.34	0.73	3.76	0.38
6	30.94	0.85	1.58	0.16
7	41.94	1.17	0.21	0.02
		859061303		
1	5.07	0.87	2.61	0.26
2	5.77	0.93	2.05	0.20
3	8.17	0.96	1.74	0.17
4	11.07	0.91	1.42	0.14
5	13.37	0.77	0.90	0.09
6	16.47	0.89	0.84	0.08
7	19.27	0.93	1.18	0.12
		859061400		
1	5.39	0.89	1.60	0.16
2	7.79	0.92	1.15	0.12
3	9.29	0.90	1.25	0.12
4	10.69	0.87	1.59	0.16
5	12.99	0.74	1.25	0.12
6	16.09	0.85	1.48	0.15
7	21.59	0.92	1.54	0.15

Table A7

Grain Size Statistics

		MOMENT STATISTICS				FOLK INCLUSIVE GRAPHIC STATISTICS				
Run ID No.	Streamer No.	FIRST MM	SECOND MM	THIRD	FOURTH	MEDIAN MM	MEAN MM	STANDARD DEVIATION MM	SKEWNESS	KURTOSIS
859051057	1	0.22	0.57	-2.64	12.32	0.20	0.20	0.56	-0.22	1.38
Trap 1	2	0.19	0.74	-0.76	6.49	0.19	0.18	0.40	0.02	1.02
	3	0.20	0.69	-0.76	5.69	0.20	0.20	0.48	-0.04	1.02
	4	0.19	0.73	-1.12	6.64	0.18	0.18	0.42	-0.10	0.96
	5	0.21	0.60	-1.38	5.49	0.19	0.19	0.65	-0.32	1.34
859051057	1	-	-	-	-	-	-	-	-	-
Trap 2	2	0.19	0.65	-2.02	10.74	0.18	0.18	0.48	-0.20	1.06
	3	0.17	0.72	-2.12	15.44	0.17	0.17	0.36	-0.07	0.98
	4	0.16	0.73	-2.12	15.22	0.15	0.16	0.33	-0.23	0.89
	5	0.14	0.79	-0.50	6.99	0.14	0.14	0.26	-0.33	0.99
859051057	1	0.16	0.79	-0.28	8.17	0.16	0.16	0.28	-0.12	0.84
Trap 3	2	0.16	0.74	-2.52	18.87	0.16	0.16	0.31	-0.08	1.02
	3	0.16	0.73	-2.00	11.99	0.16	0.16	0.34	-0.18	1.13
	4	0.16	0.75	-2.48	21.06	0.16	0.16	0.31	-0.15	0.97
	5	0.14	0.80	-0.04	6.16	0.14	0.15	0.25	-0.26	0.88
859051057	1	0.16	0.78	-0.34	6.76	0.16	0.16	0.29	-0.12	0.83
Trap 4	2	0.15	0.81	0.22	5.04	0.15	0.15	0.27	-0.09	0.86
	3	0.17	0.63	-4.24	26.28	0.15	0.15	0.32	-0.20	1.20
	4	0.15	0.81	-0.12	6.64	0.15	0.15	0.26	-0.15	0.88
	5	0.14	0.81	0.08	6.44	0.13	0.14	0.22	-0.31	1.18
859051057	1	0.16	0.78	-0.92	11.68	0.15	0.16	0.29	-0.21	0.92
Trap 5	2	0.15	0.80	-0.32	5.86	0.15	0.15	0.26	-0.25	0.82
	3	0.15	0.81	-0.08	5.62	0.15	0.15	0.26	-0.14	0.94
	4	0.14	0.82	-0.32	4.91	0.14	0.14	0.25	-0.26	0.91
	5	0.14	0.78	-1.16	9.14	0.14	0.14	0.26	-0.27	1.04

(Continued)

Table A7 (Continued)

		MOMENT STATISTICS				FOLK INCLUSIVE GRAPHIC STATISTICS				
Run ID No.	Streamer No.	FIRST MM	SECOND MM	THIRD	FOURTH	MEDIAN MM	MEAN MM	STANDARD DEVIATION MM	SKEWNESS	KURTOSIS
859051057	1	0.16	0.76	-1.22	12.72	0.16	0.16	0.80	-0.16	0.89
Trap 6	2	0.16	0.75	-1.16	7.34	0.15	0.16	0.78	-0.28	0.98
	3	0.15	0.78	-0.38	5.71	0.15	0.15	0.81	-0.02	0.95
	4	0.15	0.79	-0.42	5.72	0.14	0.15	0.82	-0.34	0.78
	5	0.14	0.78	-0.62	6.91	0.14	0.14	0.82	-0.03	0.96
859051057	1	0.18	0.62	-2.52	12.44	0.17	0.17	0.72	-0.28	1.27
Trap 7	2	0.17	0.65	-2.26	11.02	0.16	0.16	0.74	-0.36	1.16
	3	0.16	0.66	-4.22	27.96	0.15	0.15	0.81	-0.25	0.93
	4	0.18	0.52	-2.92	11.98	0.15	0.16	0.62	-0.54	2.62
	5	0.14	0.80	0.08	6.28	0.14	0.14	0.84	-0.26	0.91
859061018	1	0.16	0.79	0.28	5.24	0.16	0.16	0.82	0.01	1.00
Trap 1	2	0.15	0.78	0.20	5.59	0.15	0.15	0.82	-0.17	0.85
	3	0.15	0.80	0.08	5.01	0.15	0.15	0.82	-0.08	0.89
	4	0.14	0.80	-0.16	5.60	0.14	0.14	0.84	-0.18	1.00
	5	0.13	0.80	0.88	5.82	0.13	0.13	0.85	-0.22	1.17
859061018	1	0.16	0.78	-0.88	9.57	0.15	0.16	0.80	-0.17	0.93
Trap 2	2	0.15	0.80	-0.22	4.53	0.15	0.15	0.82	-0.20	0.95
	3	0.15	0.82	-0.56	4.56	0.14	0.14	0.83	-0.19	1.06
	4	0.14	0.75	-2.52	17.42	0.13	0.17	0.82	-0.28	1.16
	5	0.17	0.54	-1.94	6.72	0.14	0.16	0.60	-0.64	1.96
859061018	1	0.16	0.77	-0.12	4.46	0.16	0.16	0.79	-0.10	1.00
Trap 3	2	0.15	0.78	0.56	5.89	0.15	0.15	0.82	-0.15	0.92
	3	0.15	0.79	-0.22	11.52	0.15	0.15	0.84	-0.14	0.94
	4	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-

(Continued)

(Sheet 2 of 4)

Table A7 (Continued)

		MOMENT STATISTICS				FOLK INCLUSIVE GRAPHIC STATISTICS				
Run ID No.	Streamer No.	FIRST MM	SECOND MM	THIRD	FOURTH	MEDIAN MM	MEAN MM	STANDARD DEVIATION MM	SKEWNESS	KURTOSIS
859061018	1	0.16	0.77	0.04	5.29	0.15	0.16	0.81	-0.20	0.89
Trap 4	2	0.16	0.78	0.20	5.31	0.16	0.16	0.81	-0.01	0.94
	3	0.16	0.78	-0.68	14.11	0.16	0.16	0.82	-0.05	0.94
	4	0.15	0.80	-0.04	5.78	0.15	0.15	0.83	-0.12	0.89
	5	0.14	0.75	1.34	5.20	0.15	0.15	0.76	0.00	1.07
859061018	1	0.17	0.75	-0.70	5.57	0.17	0.17	0.78	-0.09	1.14
Trap 5	2	0.17	0.76	-0.70	5.11	0.16	0.17	0.78	-0.13	1.01
	3	0.17	0.76	-1.28	12.33	0.16	0.16	0.80	-0.14	1.06
	4	0.16	0.76	-0.84	7.40	0.16	0.16	0.79	-0.12	0.98
	5	0.28	0.40	-1.08	3.06	0.19	0.29	0.41	-0.64	0.84
859061018	1	0.17	0.74	-1.34	8.73	0.16	0.17	0.78	-0.16	1.03
Trap 6	2	0.17	0.77	-1.24	8.99	0.16	0.16	0.79	-0.10	1.05
	3	0.16	0.78	-0.44	4.84	0.16	0.16	0.80	-0.10	0.95
	4	0.16	0.78	-0.54	5.56	0.16	0.16	0.81	-0.14	0.95
	5	0.15	0.78	-0.28	5.74	0.15	0.15	0.82	-0.13	0.94
859061018	1	0.17	0.76	-0.58	4.54	0.16	0.16	0.78	-0.10	1.13
Trap 7	2	0.16	0.76	-0.52	5.31	0.16	0.16	0.78	-0.14	1.00
	3	0.15	0.75	-0.30	3.89	0.15	0.15	0.77	-0.20	0.94
	4	0.21	0.54	-1.42	4.83	0.18	0.19	0.57	-0.40	1.32
	5	0.14	0.70	-1.02	5.39	0.13	0.14	0.74	-0.40	1.08
859071110	1	0.16	0.81	-0.26	3.87	0.16	0.16	0.82	-0.06	0.84
Trap 1	2	0.16	0.80	0.02	4.71	0.16	0.16	0.82	-0.04	0.91
	3	0.15	0.75	-3.40	31.08	0.15	0.15	0.82	-0.12	0.98
	4	0.15	0.81	0.04	5.21	0.14	0.15	0.84	-0.20	0.91
	5	0.14	0.80	-0.36	5.98	0.14	0.14	0.84	-0.28	1.11

(Continued)

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Table A7 (Concluded)

		MOMENT STATISTICS				FOLK INCLUSIVE GRAPHIC STATISTICS				
Run ID No.	Streamer No.	FIRST MM	SECOND MM	THIRD	FOURTH	MEDIAN MM	MEAN MM	STANDARD DEVIATION MM	SKEWNESS	KURTOSIS
859071110	1	0.16	0.78	-0.52	5.22	0.15	0.16	0.80	-0.20	0.94
Trap 2	2	0.16	0.79	-0.20	4.21	0.16	0.16	0.81	-0.05	0.88
	3	0.15	0.81	-0.04	5.36	0.14	0.15	0.85	-0.27	0.85
	4	0.14	0.80	-0.02	5.90	0.14	0.15	0.84	-0.34	0.94
	5	0.14	0.80	0.76	4.56	0.14	0.14	0.82	-0.16	1.20
859071110	1	0.17	0.76	-0.84	6.80	0.17	0.17	0.78	-0.01	1.04
Trap 3	2	0.15	0.81	-0.04	4.29	0.15	0.15	0.82	-0.18	0.94
	3	0.16	0.80	-0.18	4.28	0.16	0.16	0.82	-0.04	0.88
	4	0.15	0.78	0.22	4.72	0.15	0.15	0.81	-0.21	0.84
	5	0.14	0.80	0.78	4.86	0.14	0.14	0.81	-0.13	1.02
859071110	1	0.19	0.70	-1.88	11.37	0.18	0.18	0.75	-0.13	1.13
Trap 4	2	0.19	0.72	-1.30	7.32	0.18	0.18	0.75	-0.06	0.99
	3	0.17	0.75	-0.92	5.89	0.17	0.17	0.77	-0.14	0.96
	4	0.16	0.79	-0.56	4.94	0.16	0.16	0.80	-0.04	0.91
	5	0.15	0.78	0.08	4.81	0.15	0.15	0.81	-0.22	0.96
859071110	1	0.18	0.69	-1.88	12.10	0.17	0.17	0.76	-0.11	1.00
Trap 5	2	0.18	0.74	-1.32	10.39	0.18	0.17	0.78	-0.05	1.12
	3	0.16	0.77	-0.30	5.82	0.16	0.16	0.80	-0.14	0.91
	4	0.17	0.65	-0.80	6.86	0.17	0.17	0.80	0.02	0.98
	5	0.16	0.77	-0.44	5.40	0.16	0.16	0.80	-0.14	1.01
859071110	1	0.18	0.72	-0.52	5.71	0.17	0.18	0.75	-0.10	1.00
Trap 6	2	0.17	0.75	-0.78	9.12	0.16	0.17	0.77	-0.16	0.97
	3	0.17	0.74	-1.04	11.54	0.16	0.17	0.78	-0.19	0.94
	4	0.17	0.77	-0.52	7.27	0.16	0.17	0.79	-0.13	0.98
	5	0.16	0.73	-0.88	6.45	0.16	0.16	0.77	-0.26	0.95
	6	0.14	0.78	0.96	4.53	0.14	0.15	0.80	-0.04	1.14

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APPENDIX B: NOTATION

Δa	Distance between nozzles, m
c	Empirical coefficient to convert wet weight to dry weight
DW	Dry weight of sediment, kg (force)
F	Sand flux (measured), kg/(m^2-sec)
FE	Sand flux (estimated), kg/(m^2-sec)
Δh	Height of streamer nozzle, m
H_b	Average significant breaking wave height, m
H_{mo}	Spectrally based significant deepwater wave height, m
i	Transport rate density, kg/(m-sec)
I	Total longshore sand transport rate, N/sec or kg/sec
k	Streamer number
N	Total number of streamers in a trap
R	Discharge parameter, m^3/sec
S	Weight of sand, kg (force)
Δt	Sampling time interval, sec
T_p	Peak spectral period, sec
V	Average longshore current speed, m/sec
WW	Weight of sediment in drip-free condition, kg (force)
Δw	Width of streamer nozzle, m
x	Distance alongshore, m
X_b	Average width of the surf zone, m
y	Distance offshore, m
z	Depth along the profile, m

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